

MARCH 17, 1960

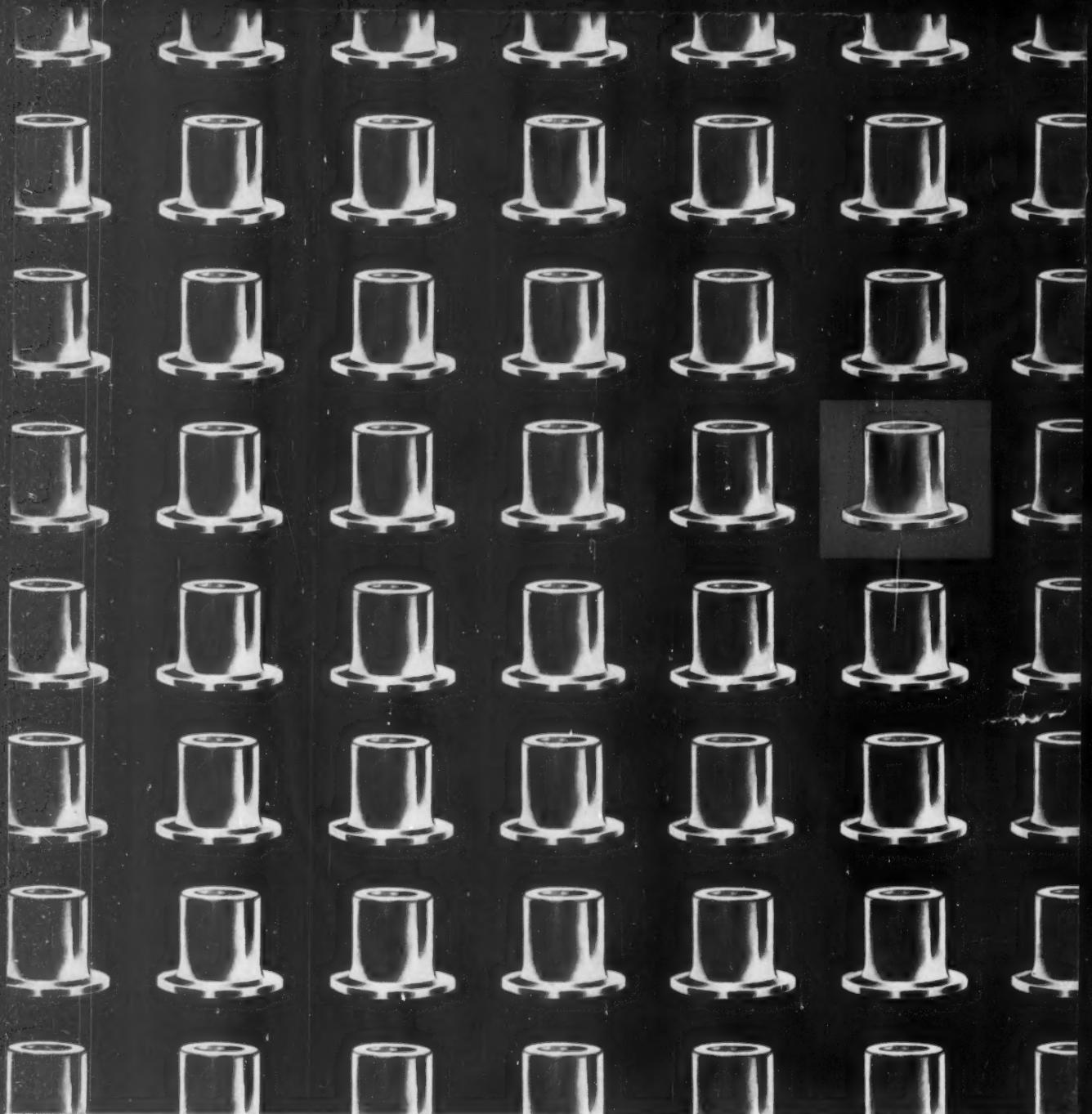
MACHINE

# DESIGN

A PENTON PUBLICATION - BIWEEKLY

**Coarse or Fine Threads?**

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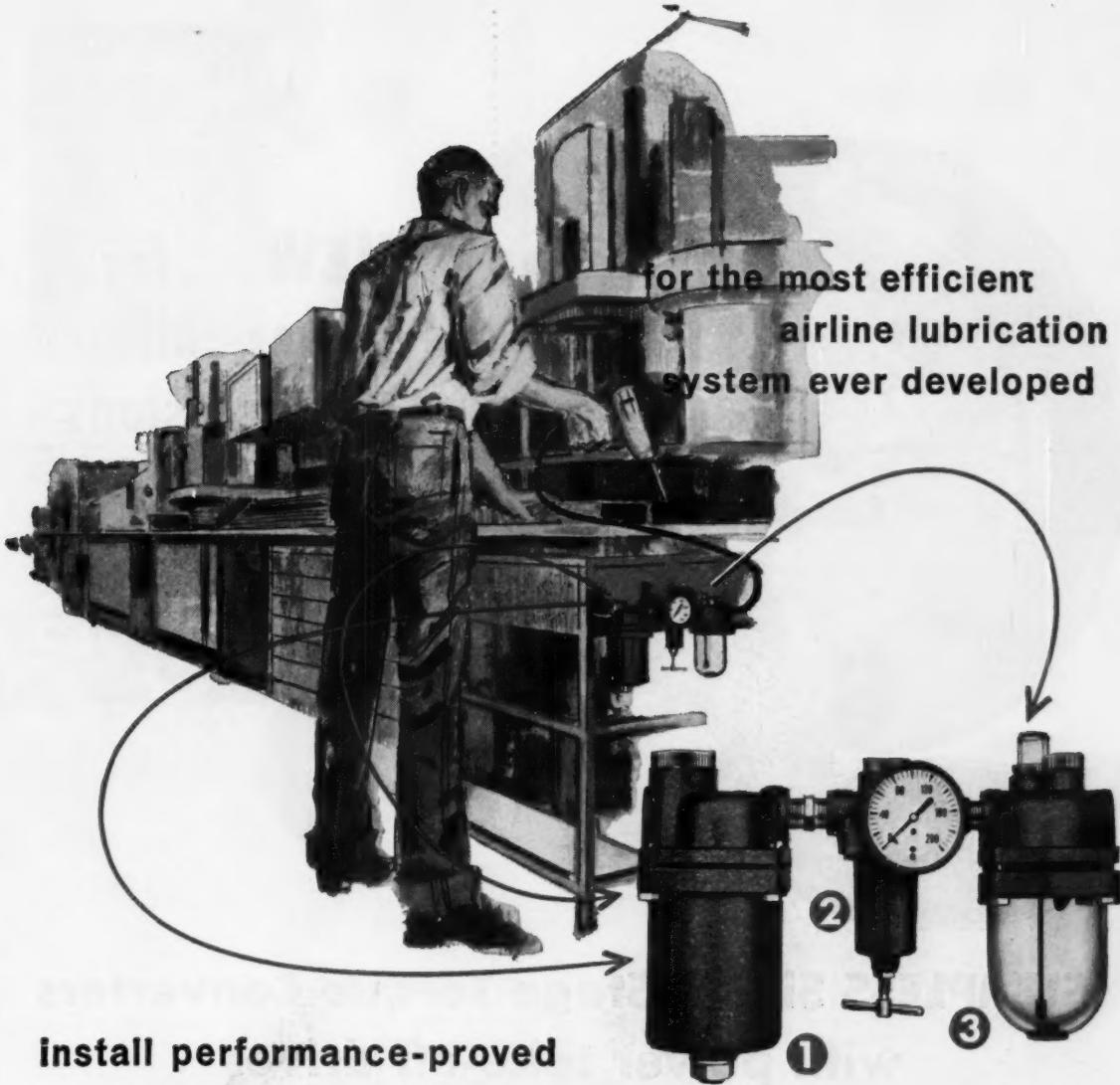


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Circle 401 on Page 19

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age to sensitive airline devices. Handles all airline pressure up to 200 PSI and flow volume from 5 to 50 CFM.

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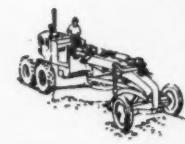
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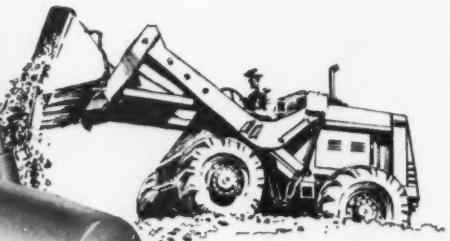


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DIVISION  
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power-shift  
transmissions**



## **SUMPLESS Single-Stage Torque Converters with power take-off drives**

From the world's largest manufacturer of industrial torque converters comes a new line of sumpless units . . . torque converters designed specifically for use in front-end loaders, tractors, motor graders and other vehicles with power-shift transmissions. One of these Twin Disc converters will make an ideal drive-line partner for the power-shift box on your drawing board.

Sumpless Twin Disc Torque Converters are single-stage units furnished in three different input torque capacity sizes: 1300 Series, 350 lb-ft; 1500 Series Standard-Duty, 450 lb-ft; and 1500 Series Heavy-Duty, 650 lb-ft.

All models have a PTO point normally used as a power implement

pump drive. A second PTO point is furnished on the 1300 Series only. This is a lower capacity drive likely to be used for a steering pump on vehicles with power steering.

A pump for circulating the converter fluid through a cooler is standard equipment. On the 1500 Series units an optional duplex pump can be furnished. One side acts as the converter circulating pump while the other side provides a pressure head for actuating hydraulic clutches, cooling clutch plates and lubricating bearings in the power-shift transmission. Both pumps are furnished in a choice of two capacity sizes depending on cooling requirements. Where sumpless torque converters are used, the plumbing must be integrated into

the transmission system, or an independently mounted sump supplied by the equipment manufacturer.

Bulletin 510 gives details and specifications on the complete line of Twin Disc Single-Stage Torque Converters. Write for your copy today. **TWIN DISC CLUTCH COMPANY, Racine, Wisconsin; Hydraulic Division: Rockford, Illinois.**



**TWIN DISC**  
Torque Converters



March 17, 1960

**Front Cover:** More than zigzag lines, George Farnsworth's cover design shows how coarse and fine threads of the same nominal size would look if superimposed. Both thread types are examined in Bill Weltermire's article on Page 134.

**B-70: Last of the Air-Breathing Bombers . . . . . 24**

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effective automation  
begins before the start  
with COORDINATED CONTROL

Automatic control, the vital element which helps make automation and its many important production benefits possible, involves much more than top quality control equipment. And for most effective automation, automatic control begins long before the start-up—should in fact be the starting point for automation planning.

Today, automation's demanding need for greater effectiveness through continuous, controlled operation, can only be fulfilled by coordinated control—automatic controls designed with a thorough knowledge of, and completely integrated with, all the elements which comprise an automated process, system, or machine.

Since automatic control is the "nerve center" of industry's highly complicated electrical drive systems, only a control specialist is best qualified to coordinate these systems—a control specialist whose product and industry trained engineers work as partners with engineering and manufacturing personnel, consulting engineers, contractors and other equipment suppliers.

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For concept to start-up coordination of the automatic control in your particular operation contact your nearest Clark Controller sales office. Or, write direct to The Clark Controller Company.

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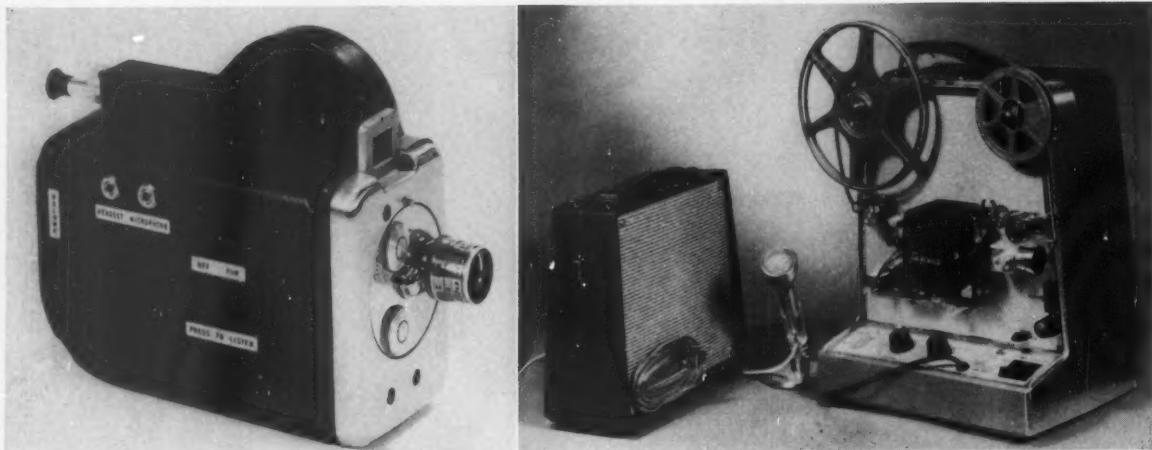
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CLARK CONTROLLER CO.  
CLEVELAND, OHIO



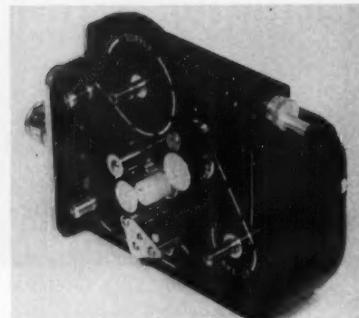
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**ENGINEERING NEWS****End of the Silent Era in Home Movies**

**First 8-mm home movie camera** to record pictures and sound simultaneously is a completely self-contained battery-powered unit. Developed by Fairchild Camera and Instrument Corp., Syosset, N. Y., and called the Cinephonic Eight, the camera contains a constant-speed motor and a five transistor amplifier powered by a rechargeable nickel-cadmium battery. The microphone attachment picks up sound at distances ranging to 9 ft; one pushbutton controls both sight and sound. Design of the camera was made possible by the recent development of sound recording on extremely narrow magnetic stripes. Film for the Cinephonic Eight has a thin magnetic stripe along its edge. The versatile projector-recorder, designed for use with the camera, has a built-in sound amplifier and uses a separately housed speaker unit and microphone. It not only plays back a 400 ft roll of film, but can also erase, overlay, or record fresh sounds as desired.

**Plug-In Electric Shovel—World's Biggest Earthmover****Coal Mining Becomes  
A Mere One-Man Job**

MILWAUKEE — The largest mobile land machine in the world, destined for use in the Kentucky coal fields, is in final stages of design at Bucyrus-Erie Co., Milwaukee, Wis. The mammoth stripping shovel will have a dipper capacity of 115 cubic yards and will weigh about 14 million pounds. It will require as much electric power as a city of 12,000 people.

The Bucyrus - Erie engineering team assigned to the shovel offer these statistics to further underscore the size of the machine:

- The shovel boom will tower 210

ft in the air—as high as the deck of the Golden Gate Bridge, 56 ft higher than the Statue of Liberty.

- In 50 seconds, the machine will pick up 173 tons of material, dump it 464 ft away (distance of a city block), and swing back for the next bite.
- Overburden removed by the machine in one month could fill all the cars in a train stretching from Chicago to Pittsburgh.

Fifty-two electric motors, ranging in size from  $\frac{1}{4}$  to 3000 hp (for a total of 12,000 hp) will operate and propel the shovel. Main power source will be a "trailer cable" hooked to the nearest 6900-volt ac



**Startling size** of the Bucyrus-Erie shovel is indicated by this artist's conception.

Salt River Valley Water Users Association,  
Phoenix, Arizona

# Saves \$699.00 per pump...

by using ground and polished



The men who operate the "Salt River" project have the job of supplying water to 240,000 acres of land in Arizona, where the Gila River joins the Salt River. The Association maintains some 250 deep well pumps to help supply the required water.

Richard Juetten, Supervisor of Salt River's Pump Division, reports that the use of La Salle FATIGUE-PROOF steel bars has permitted a saving of \$699.00 per pump . . . a potential saving of \$174,750 when applied to the 250 pumps now in operation.

Mr. Juetten's report follows:

"I have figured our direct saving realized by using La Salle FATIGUE-PROOF steel bars in place of standard C-1045 steel shaft in our deep well turbine pumps.

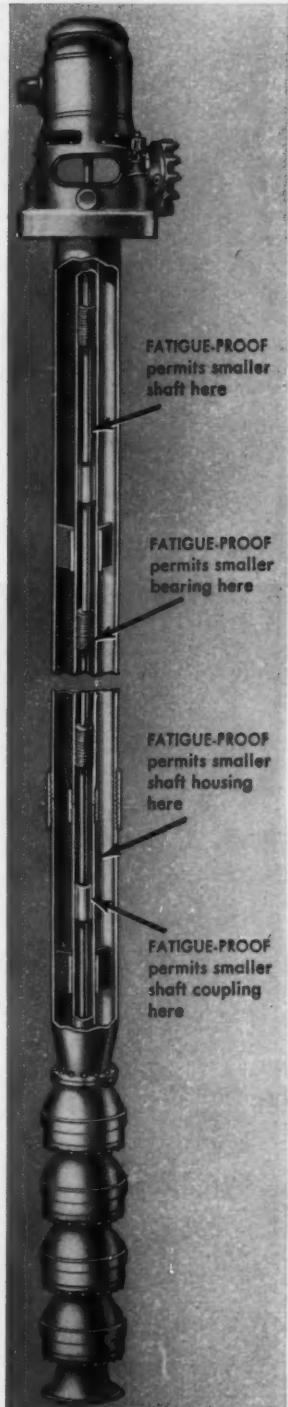
"FATIGUE-PROOF enables us to use bars only  $1\frac{11}{16}$ " in diameter . . . instead of  $2\frac{3}{16}$ " diameter shafts which were necessary when we used C-1045 . . . and this despite higher horsepower, more weight, and additional pump bowl assemblies.

"Here are comparative costs per 10-foot section (of a 300-foot pump shaft):"

using C-1045	
10' x 2-3/16" dia. shaft.....	\$28.30
3½" shaft housing.....	26.30
2 bearings, 3½" x 2-3/16".....	21.72
Shaft coupling.....	5.16
TOTAL cost.....	\$81.48
Cost per foot.....	\$ 8.15

using FATIGUE-PROOF	
10' x 1-11/16" dia. FATIGUE-PROOF	\$22.59
3" shaft housing.....	19.80
2 bearings, 3" x 1-11/16".....	13.46
Shaft coupling.....	2.34
TOTAL cost.....	\$58.19
Cost per foot reduced to.....	\$ 5.82

RESULT: A saving of \$2.33 per foot . . . or \$699.00 when applied to a 300-foot pump setting. And this doesn't take into consideration reduced power consumption.



**La Salle** STEEL CO.  
1426 150th Street  
Hammond, Indiana

ASK FOR 24-PAGE BOOKLET—It tells the complete story of FATIGUE-PROOF®

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power line. This in turn will supply electricity to the shovel's four 3000-hp dc generator sets. Crowd, hoist, and swing motions (boom and bucket motions) are powered as follows: Crowd—two 500-hp dc mill motors; hoist—eight 625-hp mill motors; swing—six 500-hp motors. The shovel is propelled by eight 250-hp wound-rotor motors, one to each track. Tracks (8-ft high) are mounted in pairs and steered hydraulically.

The entire machine will be supported by four hydraulic cylinders, each independently and automati-

cally operated to keep the machine level at all times. Bore and stroke of the cylinders: 54 in. by 80 in. The complete hydraulic system will require 4000 gallons of fluid for operation.

A single operator, located in an air-conditioned cab five stories above ground, will control the shovel. All operations will be controlled by just two hand levers and two foot pedals. Full loads will be accelerated from 0 to 25 mph in 8 seconds, decelerated from top speed to stop in 4 seconds. Motors will require 500,000 cu ft of cooling air per minute.

## Giant Antenna Is a "Precision" Instrument



**Tolerance of 3/16-inch** was maintained in building this 84-ft diameter radar tracking antenna, which is now being tested for the Air Force's Ballistic Missile Early Warning System (BMEWS). One of the largest ever built, the antenna and its support pedestal are taller than an eight-story building and weigh almost 375,000 lb; yet the dish is capable of precision rotation and can scan the skies completely in seconds. At a BMEWS installation, the radar will pick up a hostile missile and electronic computers will determine its path, giving about 15 minutes' warning to the probable target location. Goodyear Aircraft is building the antennas and 140-ft plastic radomes for Radio Corp. of America, prime contractor for the program.

## Topics

A convertible and a motor boat, for "under \$3000," come as a package deal in a German-made vehicle. The Amphicar, 85 per cent car and 15 per cent boat, looks like a convertible when ashore and like a tail-finned motor boat in the water. It's coming to the U. S. in April to take part in the International Automobile Show in New York.

• • •

Tough skiing caused by no snow becomes much easier with a recently patented plastic ski mat. The mat, which goes over a layer of sawdust, is made of ethylene webbing with rounded glass fiber projections, or knobs. A central groove in the bottom of the ski runs over a row of the knobs, giving the skier direction control. A ski, spanning three rows of knobs, is supported mainly by the two outer rows. The plastic mat has been used by its inventor, Jacques A. Brunel, at the park he manages, as well as at other ski runs.

• • •

About as popular as an umpire, the weather man is becoming scarce. This situation is brought to light by a report that Weather Bureau representatives have visited the University of Michigan to recruit meteorologists. Weather forecasting is, of course, only a very small part of meteorology, a science which is receiving increasing demands from industries such as transportation, construction, and even advertising.

• • •

New national standard for the meter will be the length of a wave of light from krypton 86. A meter will be equal to 1,650,763 wave lengths of light emitted by an atom of the gas. This standard will be adopted by the U. S.—and probably by the rest of the world—within a year. Our present length standard is a bar of platinum-iridium which is stored in a vault in Washington. Because krypton 86 occurs naturally throughout the world, it has the advantage of availability; measurement of its light wave is also more accurate than the metal bar.

• • •

Built-in bacteria battler will come with every toy, waste basket, door knob, or arm rest made of a new Dow polyethylene. Surfaseptic was developed with a lasting effectiveness for killing disease-producing organisms. In laboratory test of Surfaseptic toys with representative strains of harmful bacteria, the material laid bacteria low during the normal life of the toy.



Exclusive TECHNIPLANNER Scale Models  
GLOBE-WERNICKE Office Equipment Sales



This G/W Techniplanner kit includes molded thermoplastic parts for a wide diversity of office "space control" layouts.

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Bringing to life before the customer's eyes his complete office layout, The Globe-Wernicke Co. uses these Quinn-Berry precision molded thermoplastic scale models. G/W sales engineers say, "Space Control here becomes a reality—one look replaces a thousand words".

Of course successful production of these precision parts requires careful choice of the correct thermoplastics, skillful mold design, dependable press room craftsmanship. These capabilities have gained for Quinn-Berry its enviable reputation as resourceful molders of precision thermoplastic parts—a reputation which invites the unusual. Place your component parts requirements with Quinn-Berry where the Unusual is Routine.

WE FLY TO SERVE YOU FASTER!



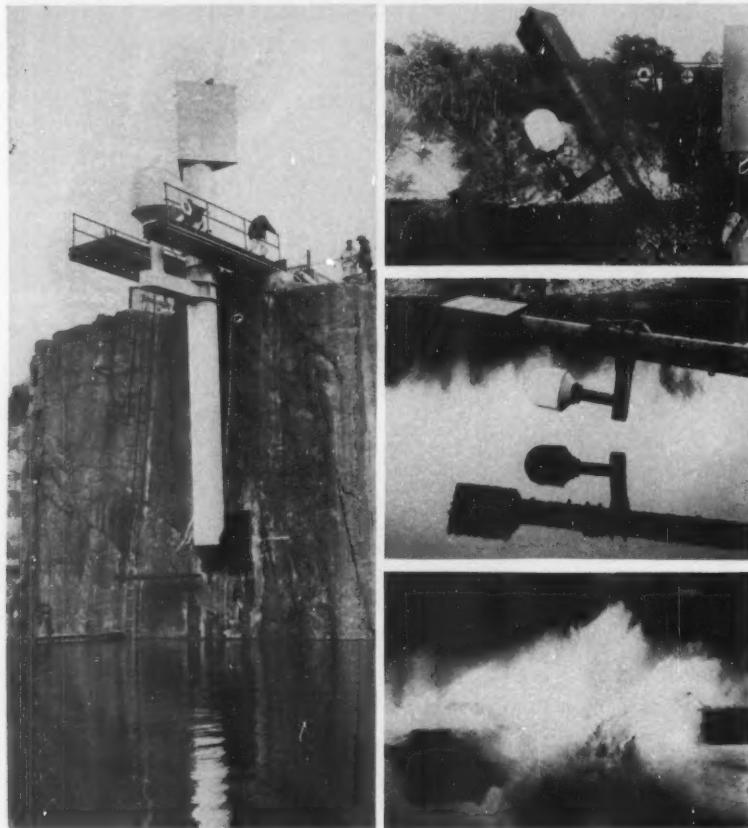
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THERMOPLASTICS



## High Dive for Polaris Parts



**Occupational hazards of submarine duty** are being simulated by this unusual test rig. It's designed to check out navigational radomes for Polaris submarines. Radomes are attached to the 40-ft pendulum (which is ruggedly hinged to the cliff of an abandoned quarry) and plunged into the water to simulate the smashing impact of high seas. The radomes house a precision antenna assembly for the Polaris sub's unique radiometric sextant—a device that permits the submarine navigational officer to "shoot the sun" or the moon by zeroing in on their radio signals. Nortronics Div., Northrop Corp. is designing the gear for the Navy.

## Irradiated Diamonds Studied As Possible Semiconductors

JOHANNESBURG, S.A.—A high-voltage electron accelerator, installed in the Diamond Research Laboratory of De Beers Consolidated Mines, Ltd., will be devoted exclusively to the study of radiation effects on the physical properties of diamonds.

Due to their conductivity properties, diamonds are already known to have potential applications in electronics. For example, certain types are semiconductors, and it has been found that their electrical resistance varies considerably with slight changes in temperature. An

electrical apparatus linked with a semiconducting diamond will immediately register temperature changes as small as 0.05 degree C. Supersensitive thermometers of this type would be extremely valuable in medicine for recording minute temperature changes in the skin and other parts of the body. Industrial applications also exist for sensitive thermometers.

Semiconductive diamonds could also serve efficiently as point-contact transistors with the special advantages that the diamond transistors can be subjected to large fluctuations of temperature without damage or loss of efficiency.

## Gas-Turbine Performance Proves Better Than Expected

HOUSTON—"Power output and efficiency [of gas turbines] have, in all cases, surpassed the calculated and guaranteed values," Swiss engineers E. Aguet and J. von Salis told the ASME Gas Turbine Power and Hydraulic Conference last week. "Favorable and trouble-free operating experiences," they continued, "prove that present-day stationary gas turbines can fully satisfy industrial requirements."

The two Swiss experts and, later, a German (F. K. Konig, managing director, Huttenwerk Rheinhausen) urged American industry to more universally adopt this type power plant. It is especially suitable for producing electricity for iron and steel industries, they claimed, because it uses the by-product of blast furnaces as fuel.

American experts also recommended the gas turbine to electrical utilities for peak-load operation. Not only are the turbines cheap to operate, reliable, efficient, and able to work up to peak load quickly, but they can use any normally available fuel.

## Recording Head



**Visual-manual co-ordination** is recorded on film by this unique camera. Worn like a hat, it simultaneously photographs the wearer's eye movement and the objective within the optical field of view. Human-factors experts at Federal Aviation Agency are using the device as an aid in pilot-training analysis. Designer of the camera, Par Products Corp., Santa Monica, Calif., suggests that studies correlating eye-movement and field of view could yield valuable design and training information for all types of vehicles.



Photo courtesy of Heintz Division—Kelsey Hayes Corporation

## Aristoloy meets severe cold extruding requirements on track bushings for Caterpillar Tractor Company

On the backward extrusion of this track bushing a 3 x 5-inch hollow blank is extended to 8 inches in a single blow. For uninterrupted flow of production, chemical and physical uniformity of the material is essential.

On thousands of parts Aristoloy electric furnace steel has fulfilled the stern production requirements of cold extruding.

Controlled melting of selected scrap, careful rolling and precise heat treating and finishing, this is why Aristoloy is so ideally suited to high volume production where rejects caused by material faults and deficiencies can be so costly.

For complete information about Aristoloy leaded or standard carbon, alloy and stainless grades, call the Copperweld representative in your nearest large city . . . or write today for NEW PRODUCTS & FACILITIES CATALOG.



**COPPERWELD STEEL COMPANY**

**ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N.Y.**

March 17, 1960

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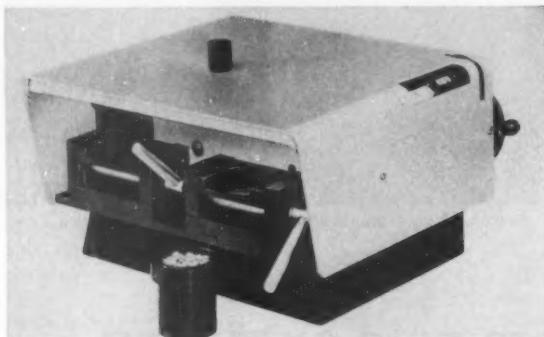
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## Two Walls Better Than One for Re-entering Spaceships

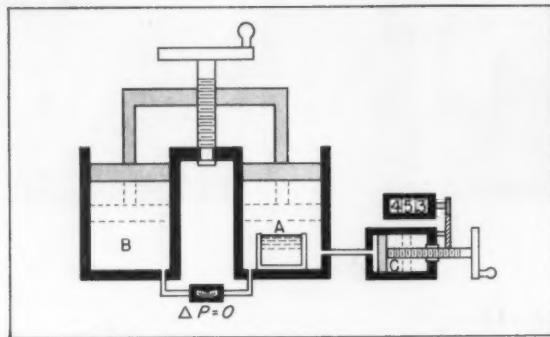
**Double-walled structure**, developed by Bell Aircraft Corp. to survive re-entry into the earth's atmosphere from outer space, consists of a radiation shield, thermal insulation, and a liquid-cooled layer. The outer wall, functioning as a heat shield, is built up of small, expandable panels made of heat-resistant metal. Purpose of this construction is to radiate some of the heat away from a vehicle's surface. Tubes or passages in the structure's inner wall permit circulation of a cooling liquid—probably water—which can be discharged as steam. A section of the structure is held by Anthony Marchese, left. Besides space vehicles, the insulated material is expected to find use in high-speed aircraft, such as the model held by another Bell engineer, Anthony Mirti, right. The company has received an Air Force contract to develop manufacturing methods for production of the material.



## Volume Measurement by Balanced Air Pressures



**Volumes of granular, irregular, or porous solids** can be directly measured on a new Houston Instrument Co. pycnometer. Two cylinders (A and B) have equal volumes and a third (C) acts as a pressure balancing device. The relief cylinder contains a piston with a calibrated stroke, and movement of the piston registers on a counter. Sample to be measured is placed in A, and A and B pistons



are stroked down. Pressure is then greater in A (air in that cylinder has been compressed to a smaller percentage of its original volume). The piston in cylinder C is retracted until pressures in A and B are equal. Volume of air withdrawn, read directly from the counter, is the correct sample volume when pressures in the two cylinders are equal. Accuracy of pycnometer with 50-cc sample is 0.1 cc.

### Radiation-Tolerance Tool: Plastic Man Enters the Hot Lab

**ANN ARBOR, MICH.**—Lethal doses of gamma, beta, and x-ray radiation are being focused on a transparent man-like figure at the University of Michigan where researchers hope to tie down shielding variables and determine once and for all how much radiation man can withstand.

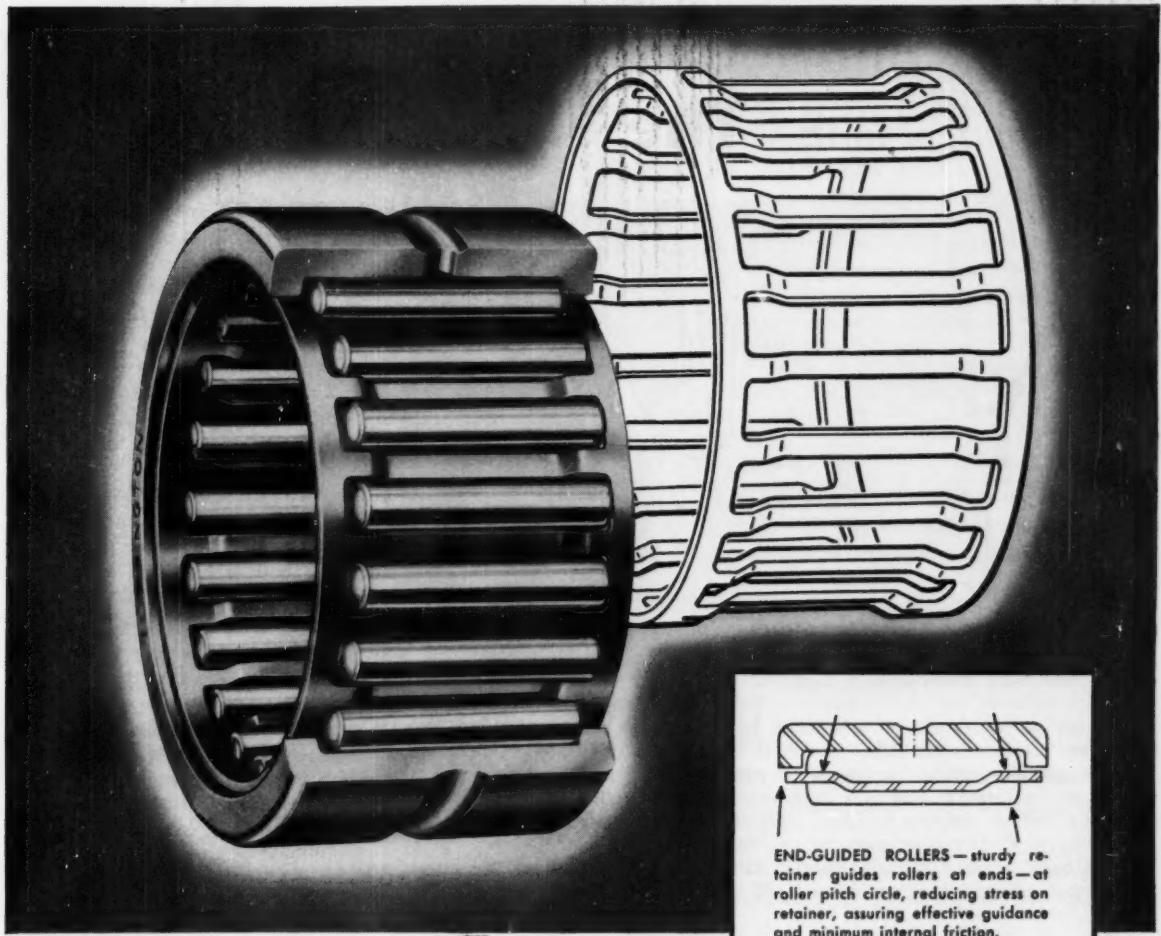
The plastic man is built around a human skeleton. He stands 5 ft 9 in. tall and is shaped like a man weighing 162 lb. He has foam-plastic organs and his joints are hinged. Organs and body cavities can be filled with an organic solution which has the exact density and composition of human flesh. Measuring devices can be placed inside his body.

Researchers are currently using

the device to determine:

- Amount of radiation reflected by the body.
- Radiation received by various parts of the body.
- Penetrating power of the radiation.

Future plans include using the mannequin to recreate radiation accidents that have occurred in industry.

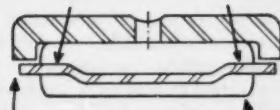


*The New Torrington Heavy Duty Roller Bearing*

## Key to Long Life... Roller Guidance Where It Counts!

This sturdy flange-riding retainer in Torrington Heavy Duty Roller Bearings insures the highest degree of roller guidance where it's most effective...at the roller ends along the pitch circle. You get outstanding service life through minimum internal friction, high roller stability and efficient lubrication.

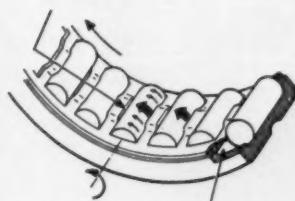
Controlled contour rollers prevent high end-stress concentrations. Careful heat treatment of the channel-shaped outer race insures high shock resistance. The Heavy Duty Roller Bearing has proved successful under unusual conditions of deflection or misalignment. Torrington Heavy Duty Roller Bearings are giving longer life in such difficult applications as two-cycle engines, hydraulic pumps, oil-field equipment, sheaves and transmissions. For design and application assistance on the Heavy Duty Roller Bearing—and every basic type of anti-friction bearing—call your Torrington District Engineer.



**END-GUIDED ROLLERS**—sturdy retainer guides rollers at ends—at roller pitch circle, reducing stress on retainer, assuring effective guidance and minimum internal friction.



**UNIFORM LOADING**—Torrington controlled contour rollers eliminate stress concentration at roller ends. End-stress pattern of unrelieved cylindrical rollers is shown in black outline. Area in gray shows uniform loading over entire contact length of Torrington rollers.



**AMPLE LUBRICANT STORAGE AREA** is provided by the retainer design, which also allows unrestricted flow of lubricant within the bearing.

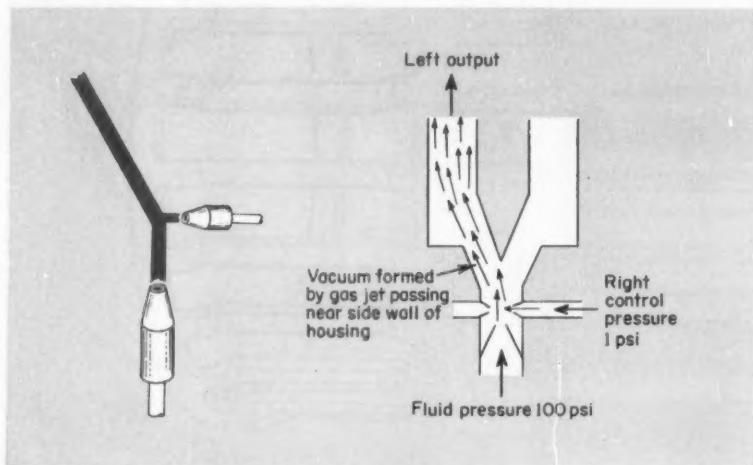
**TORRINGTON BEARINGS**

**THE TORRINGTON COMPANY**

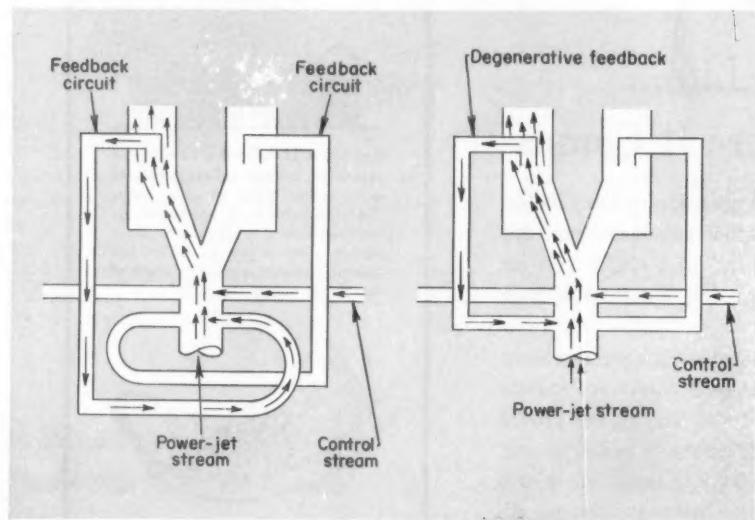
Torrington, Conn. • South Bend 21, Indiana

*Army develops  
a new control unit:*

## The Fluid Triode



Army's new fluid triode uses two control jets to "switch" a power jet back and forth between two output apertures (left). If a steady (reference) pressure is imposed on one control jet (analogous to a grid bias) the power jet switches each time pressure to the other control jet passes through the reference value. Bistable operation results from design of passageways (right). Sucking action of the jet on the sidewall creates a local vacuum that locks the jet in place, even when the output aperture becomes blocked. Units using vacuum locking are very sensitive to control-jet pressure and can operate as amplifiers with gains as high as 100, i.e., 1 psi unbalance in control pressure will switch the power jet if input pressure does not exceed 100 psi.



**Feedback alters control characteristics.** When feedback reinforces control-jet action (left), stability becomes greater. The power jet can be so stubborn that large changes in control pressure are necessary to cause it to switch. Flip-flop units of this design are expected to find uses where control pressures fluctuate and slow switching response is desired. When feedback is degenerative, i.e., when it opposes control-jet action (right), the power jet switches back and forth with little regard for control pressure. When control jets are eliminated from the degenerative unit, the device becomes a true fluid oscillator with a natural frequency that depends on length of passageways and length of feedback tubing.

HYDRAULICS may soon take over some of the jobs now assigned to electronic systems. A new control principle makes practical some fluid-operated devices that are analogous to electron tubes.

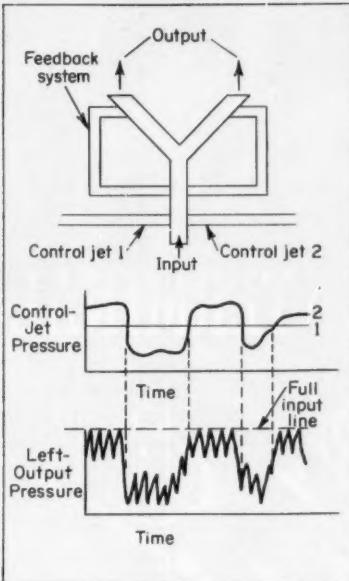
Prototypes have been developed by Diamond Ordnance Fuze Laboratories, Washington, D. C. Action of the units depends on the collision between low-pressure control jets and a high-pressure power jet. And like the grid of a vacuum tube, control jets of the fluid triode can accept both a bias and a superimposed alternating signal.

Army spokesmen aren't talking about applications—military uses are confidential—but they will say that the fluid triode can "memorize," count, amplify a signal, perform logic operations, and regulate time intervals. Push-pull and flip-flop concepts, usually associated with electronics, are applicable and amplifiers, modulators, and oscillators, can be designed.

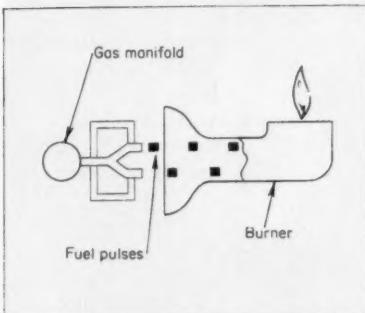
Because the control has no moving parts, it has two very useful features: It can operate at white heat when constructed of refractory materials, and it can adequately handle signals in the audio frequency band. Other features include ruggedness, reliability without maintenance, simplicity, and low cost. The Army claims that in applications where fluid-triode systems can replace electronics the fluid device will cost only 1/100 as much as a transistor or tube.

Sizes of the Army's working models vary. Miniature units that handle small flows have been constructed by printed-circuit techniques, but the control can also be built large enough to handle thousands of horsepower.

Limitations to performance are primarily due to speed of flow through passageways in the control unit. Faster than mechanical systems and slower than electronics, fluid-triode circuits will inherit some of the jobs of each. Greatest use, however, will probably be in applications that are not practical for other systems.



**Output and control** waveforms can be roughly matched by degenerative feedback—even when the device is used as an amplifier with a gain of 100. A "grid bias" is imposed on one control jet (constant-pressure reference signal) and an alternating pressure on the other. The feedback keeps the amplifier oscillating between its two operating modes while control pressure goes through one cycle. Control jets do not switch the unit, they determine relative time in each mode. When the right control jet overrides the left, the unit spends more time in the flow-left condition, and vice-versa. When control pressures are about equal the unit oscillates back and forth indiscriminately.

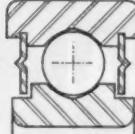


**Many jobs** could open up for the new pneumatic control. For example, a model equipped with degenerative feedback could become a fuel-pulsing device for a gas burner. Pulses of fuel would entrain more combustion air than a conventional mixer. Better combustion and higher input rates might then become possible.

## EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

PHOTO shows bearing  
ACTUAL SIZE



SIZE: 10.500" OD; 0.270" wide; 0.250" thick.  
BALL DIAMETER: 0.125"  $\pm .00025"$ .  
MATERIALS: Stainless steel.  
MAXIMUM RUNOUT OF OUTER RACE: 0.0002" TIR.  
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.  
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.

Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example —

To save space, simplify assembly and prevent operating trouble, we designed and are producing this extra-thin-section ball bearing, equipped with a built-in shield on each side in place of separate shields. The shields fit so closely that they retain the lubricant and enable the bearing to pass the standard military sand and dust storm test. This construction assures long-lived low-torque operation, and cuts both assembly and maintenance costs.

YOUR design problem might likewise be simplified or your product improved by ball or roller bearings of special section or configuration, heat resistance, corrosion resistance, ultra precision, or other unusual properties. We design and produce such bearings to individual requirements, in any size from  $1/4$ " ID to over 70" OD; and we invite your inquiries.

### FREE BULLETIN AFB-2

describes our work in this field—shows a wide variety of "specials"—tells about factors involved in special bearing applications. Write for it!



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411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
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414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566										

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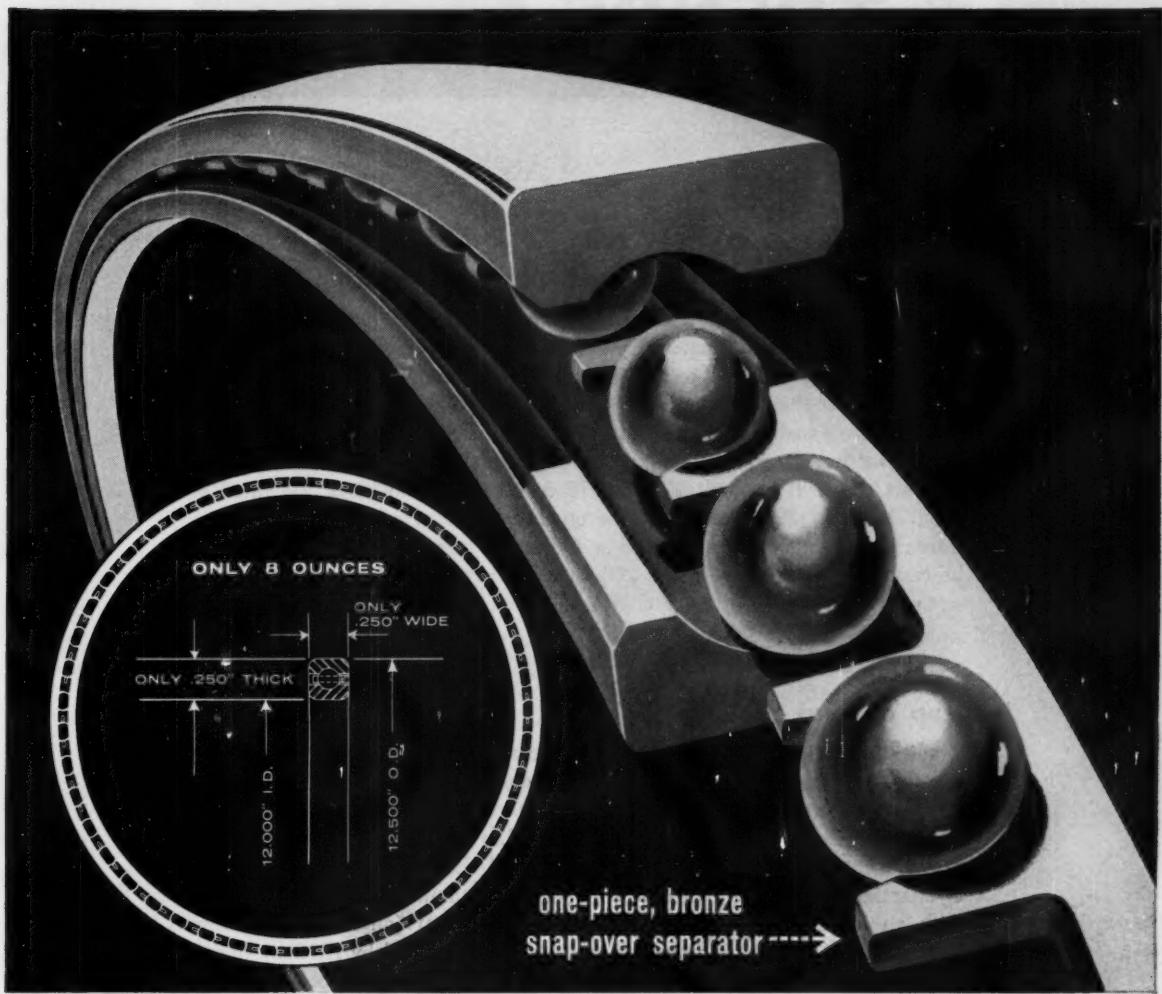
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**News from KAYDON!**

## **Real-Slim bearings "off the shelf" ...prices slashed up to 76%**

**90 sizes — 4" to 12" bore —**

**1/4" to 1" width and cross-section**

**Drastic price reductions** — on Kaydon new type "CP" Real-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

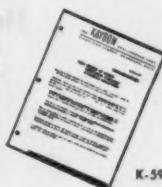
**Save on bearing cross-section and weight** — Real-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

**KAYDON**  
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**Type "CP" with new one-piece, bronze snap-over separator** — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

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**the '61 cars: more compacts and more aluminum engines**

The deluge of small cars (at least four) expected from Detroit this fall is generating rumors in geometric proportion. Most speculation now centers on powerplants. It's no secret, of course, that aluminum engines will be more common than cast-iron jobs within a very few years; the question is, how soon? Based on reports from "unusually reliable sources," the engine picture for next year shapes up something like this: Buick and Oldsmobile compact cars will be powered by a 215 cu in. aluminum block V-8 rated at about 150 hp. Front mounted, the engine will reportedly be coupled to a transaxle. Pontiac is working on a 4-cylinder engine which will probably be cast iron and displace about 200 cu in. Chrysler is now capable of converting its inclined 6-cylinder engine to aluminum for the Dodge compact.

**hold up on that rocking chair**

Traditional retirement policies—long centered around mandatory release at age 65—are probably due for major overhaul. A recent survey of 28 U. S. corporations (by *Industrial Relations News*) reveals that 25 per cent of the firms have flexible retirement systems; another 25 per cent make frequent exceptions to the 65-yr limit. Consolidated Edison Co. and American Cyanamid Co. have stretched the mandatory retirement age to 68. Faced with an impending shortage in the 35-44 age group (an inheritance from low birth rate depression days), many companies surveyed by IRN say they'll take up the slack with older workers, will use work performance—not age—as the chief retirement criterion.

**aeronautical engineers on the rise**

Current emphasis on flight and space vehicles has had an effect on courses of study chosen by engineering students. At North Carolina State College, for example, the number of aeronautical engineering students has almost doubled in the last four years. In the fall of 1955, 158 students were enrolled in aeronautical engineering, in the fall of 1958 the number had jumped to 283, and last September, there were 311.

**Italians will build nuclear merchantmen**

One of Europe's major shipbuilding firms, Italy's Cantieri Riuniti Dell' Adriatico (United Shipyard of the Adriatic), plans to build and sell nuclear-powered merchant vessels. Agreement has been reached with Babcock & Wilcox Co., New York, for propulsion-plant designs and patents—B&W designed the engines for the *N. S. Savannah*. "Harnessing nuclear energy," said B&W's president, M. Nielsen, "is a new science which does not lend itself to the usual marketing approaches. We must understand the attitudes of people abroad toward the atom before we can create markets for it." He saw the two-company agreement as a significant step.

### **expansion in electronic medicine**

Possibilities for electronics in the medical field are only beginning to be appreciated, says Paul B. Wishart, president, Minneapolis-Honeywell Regulator Co. M-H is forming a new medical instrumentation group with a solid core of specialists from several divisions that are already working along these lines. The company hopes to come up with new instruments of greater accuracy designed specifically to medical requirements. The medical profession is very much interested and is giving advice and counsel.

### **engineering curricula will have "split-level" look**

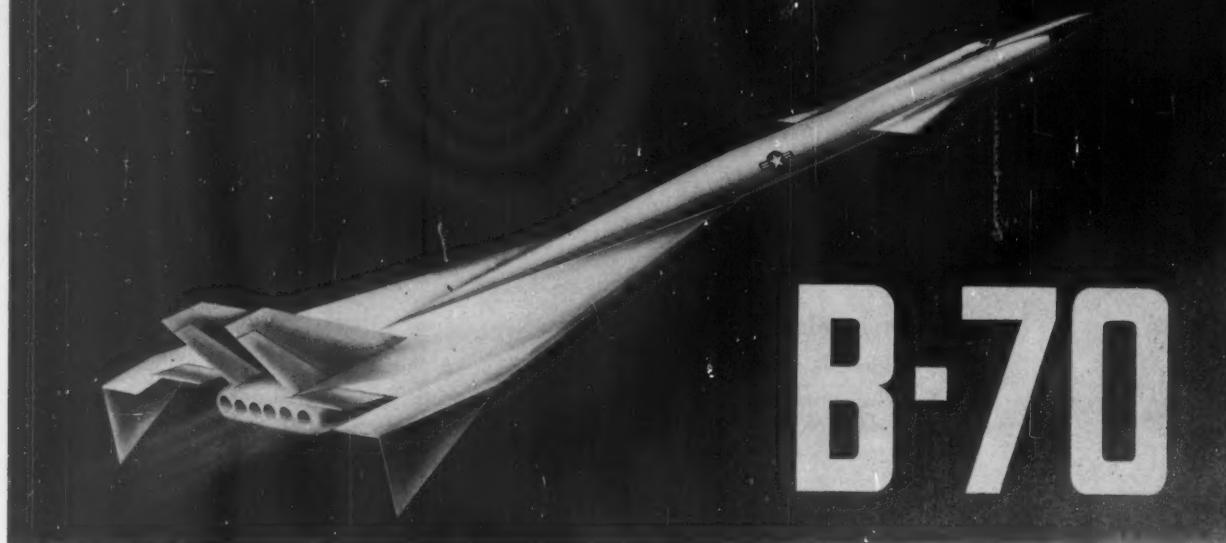
Electrical engineering is about to disappear—at least as a unified scientific discipline. It will probably split into two areas: 1. Electrophysics. 2. Electro-mechanics. This prediction, made by Brooklyn Polytechnic Institute's dean of engineering, John G. Truxal, pointed up his view of engineering as dynamic field where classic boundaries are fast disappearing. College curricula, he told a recent engineering education symposium, are due for tremendous changes—changes that will lead, according to another speaker, to a "split-level" technical education program. Professor Truxal also said that Brooklyn Polytech would announce a new, unified six-year program designed to take a student straight through from high school to a doctorate in engineering.

### **another success story for computers**

One of the recent and impressive applications of computers in engineering is reported by Westinghouse Electric Corp., where a computer is being used to accomplish almost total pre-production planning in the manufacture of large ac motor coils. The required service characteristics for the coils are fed into a Univac I computer. The computer calculates complete design specifications and prints a coil drawing with dimensions, bill of material, and other pertinent design information. The design output tape then becomes input for further data processing whereby the computer produces complete manufacturing information for the coils. This includes work station routing, detailed manufacturing operations in proper sequence, labor standards for the operations, and cost accounting.

### **battle tanks to get aluminum shoes**

Testing and field trials of aluminum track shoes on medium tanks is now completed and data, gathered at Army's Aberdeen Proving Grounds, show the tracks hold up well on the rugged tank course. Data were obtained by running aluminum and steel types simultaneously on the same track. Each aluminum forging weighs almost 3½ lb less than its steel counterpart; since a medium tank uses about 320 shoes, the 1000-lb saving is significant to the design of future equipment for modern warfare. Developer of the shoes is Kaiser Aluminum & Chemical Corp., Oakland, Calif.



# B-70

AN APPARENT CASUALTY of "pushbutton warfare," the B-70 may at least survive, in the form of several flyable prototypes, as a spectacular tribute to U. S. aeronautical knowhow. Everything about the aircraft, from fabrication to flight, can best be described in superlatives.

Even a diehard missileman would be impressed by a B-70 takeoff. With afterburners cut in, the six General Electric J-93 turbojets will develop well over 150,000 lb of thrust (vs. 80,000 lb for a B-52). This would provide all the sound and fury of a rocket launching.

And as the craft pointed its nose skyward, the crew would reach tower height before the tail cleared the runway. The plane is designed to cruise at 2000 mph for a distance of at least 6000 miles and on short missions will carry a 100,000-lb payload.

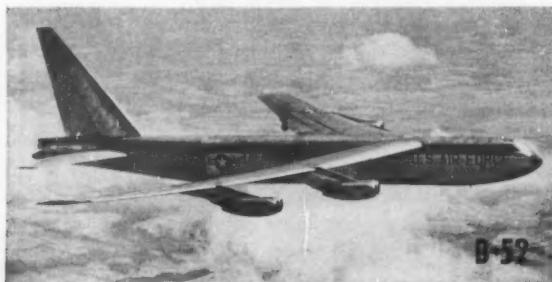
These extremes in size and power give the B-70 tremendous multi-mission potentiality:

- As a recoverable first-stage booster for satellites and Dyna-Soar type vehicles, B-70 could release orbit-bound payloads at an altitude of 70,000 ft and at Mach-3 speed.

- Conversion of the craft to an 80-passenger supersonic transport would be easy, and modification of the fuselage could double the passenger payload.

- B-70 would also be a natural for conversion to nuclear power. Its crew compartment is about 75 ft ahead of the common air intake for the engines, which would simplify the problem of personnel shielding. Side-by-side mounting of the six engines would permit one central reactor to supply heat to all.

While the aircraft itself is thus



B-52



B-70



B-47

## Sizing Up The B-70

	B-47	B-52	B-58	B-70
Gross weight, max (lb) . . . . .	200,000	450,000 +	160,000	550,000
Wingspan (ft) . . . . .	116	185	56.8	115
Length (ft) . . . . .	107	157.7	96.7	190
Speed, max (mph) . . . . .	600+	600+	1300+	2000+
Range, max (mi) . . . . .	3000+	...	...	6000+
Crew (number) . . . . .	3	6	3	4

Subject of bitter debate among top military men and administrative officials, the B-70 Valkyrie bomber will probably never be produced in combat quantity. Only two of the aircraft are now scheduled to be built under an Air Force contract with North American Aviation. Whatever its military destiny, the plane has already made engineering history: Because the designers boldly specified materials, components, and production techniques that were still in the laboratory when plans of the plane were finalized, B-70, perhaps, represents the greatest single stride in American aviation since Kitty Hawk.

## Last of the Airbreathing Bombers

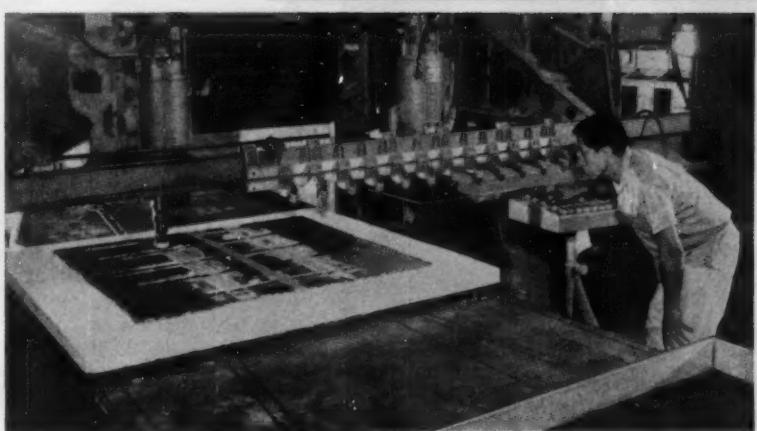
an impressive vehicle, the techniques involved in its fabrication are equally outstanding. Honeycomb sandwich will cover 75 per cent of the B-70's structure. Sheet steel, used to cover the core and other areas of the craft, is just 0.006 in. thick (increasing the thickness by 0.001 would increase the plane's weight by one ton). Forming and fastening this material were pegged as major problems in the very beginning of the B-70 program, and North American ended up designing, or initiating the design of, many of the machines now used.

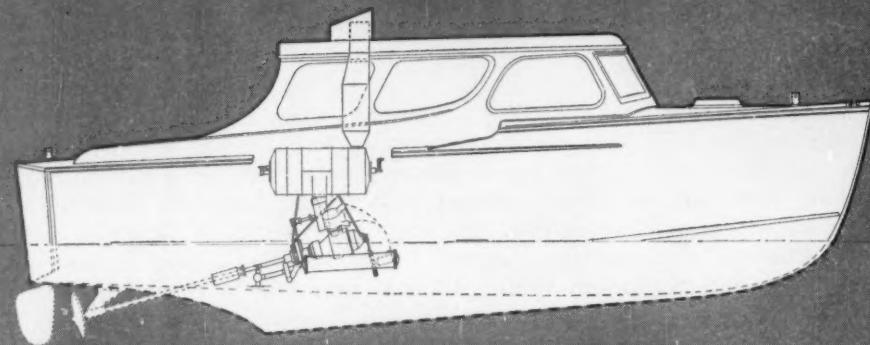
For example, welding the honeycomb skin by conventional methods was out of the question. North American had to design and build a special edge-preparation machine just to shear 16-ft sheets of steel and turn over a lip to exact dimensions (0.012 in.). Sheets are then butt-welded together, and a special roll planisher, also developed by North American, flattens the weld out so smoothly that the joined pieces seem to be one continuous sheet.

Other North American innovations include automatic machines for performing the more than 19,000 ft of fuel-tight fusion welding, and new portable equipment for brazing couplings (in 10 seconds) on steel tubing. For these and other advances in metalworking, North American was awarded the ASME 1959 Medal for the Advancement of Research.

**Perfect brazing** of honeycomb panels is assured by unusual inspection methods. Each panel is immersed in a tank filled with pure water and an ultrasonic scanning head travels over the tank, transmitting sound waves through the panel. A recording device that prints on photo-sensitized paper traces every hairline of honeycomb core that has brazed to the skin.

**Ice-chuck** solved the problem of holding honeycomb core during milling operations. Water is poured over the core, freezing and holding it to the chuck. Ice in the individual cells prevents core from deforming.





*Navy evaluates a lightweight engine as*

## **Steam Tries a Comeback**

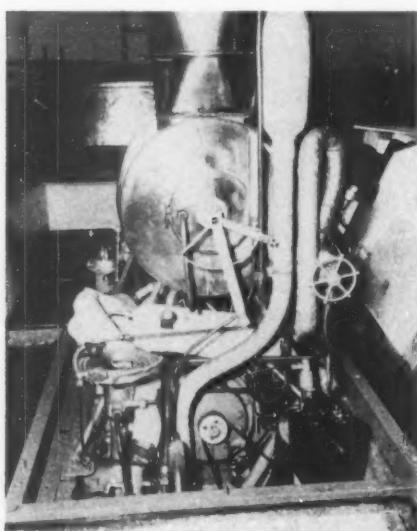
SKULDUGGERY by "vested interests"—according to unreconstructed admirers of steam propulsion—was the force that drove the Stanley Steamer to a premature and totally undeserved oblivion. Powerplant designers of that day, whether or not they subscribed to such theories, found much to admire in the compact, lightweight Stanley engine. Built with only 13 moving parts, the diminutive two-cylinder, double-acting engine developed 20-hp on 600 pounds of superheated steam. Life of the engine was alleged to be nearly indefinite and the Stanley could "climb a tree if it could catch holt!"

"Steamophiles" still active in the '60s will undoubtedly root for the success of a new, lightweight steam engine now under test at Navy's Engineering Experiment Station, Annapolis, Md. Developed by the Besler Corp., Oakland, Calif., the two-cylinder, V-type engine (compound, double-acting) was originally laid out as a small aircraft powerplant. Bureau of Ships is now checking out potentialities of the unit for small-boat propulsion.

Advantages of the new steam plant over other types (diesel and gasoline), says Navy in the *Bureau of Ships Journal*, is light weight (about 8.9 lb per hp at rated output)

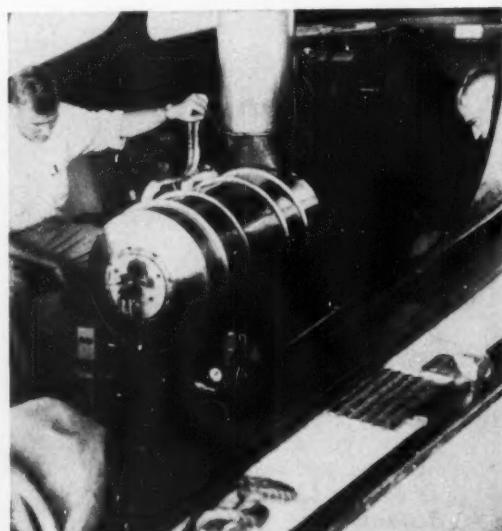
and compactness. Occupying only two-thirds of the space needed by a comparable diesel installation, the Besler engine developed an average 115 hp, drove a 28-ft personnel boat at a 16-mph clip in recent tests at E.E.S.

Weight of the engine alone is 273 lb; boiler and all equipment (dry) weigh an additional 789 lb. High-pressure cylinder has a 3-in. bore, the low-pressure cylinder a 5 $\frac{1}{4}$ -in. bore. Stroke of both is 4 in. The engine operates with 650 psi, 750 F steam; fuel consumption is 0.95 lb per bhp per hr. Makeup feedwater, which can be tap water, is about 1 gallon per hour.



**View looking aft** (photo, left) shows horizontal mounting of the forced-circulation, once-through boiler. Designed to get up steam in less than a minute, the installation will operate on any of several different fuels.

**Compact Besler powerplant** (right) occupies two-thirds volume of a comparable diesel engine. Navy and the engine builder are developing an improved steam generator for small-boat installations.



The boiler operates on a spillover cycle with approximately 10 per cent more water being pumped than can be completely evaporated. Wet steam is piped to a separator where the excess moisture is removed and then passed through a trap back to the hot well. Dry steam is taken off the top and passed back to the boiler where it is superheated to desired outlet conditions.

The burner is an air-atomizing type requiring a belt-driven air compressor. Dual electrodes and spark coils preclude ignition failure during operation. Control of the boiler is fully automatic.

Unlike the installation in the Stanley carriage, the Besler engine starts quickly: From a cold boiler, it can be put into operation in less than a minute. (Without a pilot light to keep steam up, the Stanley plant required 15 minutes or longer to get underway.) With direct, reversible drive (no clutch, transmission, or reverse gear), the Besler engine can be thrown from full-speed ahead to full-speed astern almost instantaneously.

Besler Corp. officials emphasize that the engine under test at E.E.S. is a special job, designed and constructed for a specific purpose. They have no "standard line" of off-the-shelf steam powerplants, but tailor each engine to requirements of the installation.



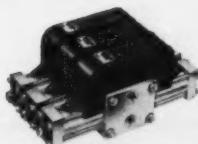
**Under test** at Navy's Engineering Experiment Station, Annapolis, this steam-powered 28-ft personnel boat makes 14 knots on 115 horsepower. Weight-to-power ratio of the dry powerplant (8.9) is about one-half that of a diesel.

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## Interim Report:

*Researchers at the National Bureau of Standards are taking a microscopic look at weaknesses in metals. No final answers are ready yet, but fatigue-failure studies are showing how to . . .*

# Build Stamina Into Metals

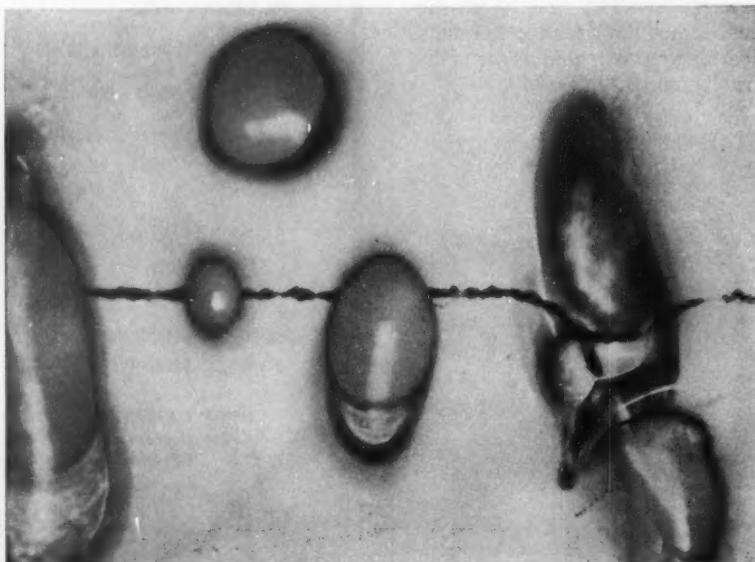
METALS won't keep pace with the demands of engineering technology unless research programs are accelerated, say National Bureau of Standards scientists. The Bureau is speeding up its efforts to understand metal behavior and is emphasizing practical new methods for developing advanced alloys. Chief needs, according to NBS, are:

- More knowledge on the effects of heat treating.
- Better insight into the mechanics of how small changes in lattice structure cause large changes in tensile and yield strengths, ductility, and hardness.

To develop the needed data, NBS researchers are scrutinizing all the unknowns they can think of, including instability in alloys, atomic changes within the lattice, surface reactions, creep, fatigue, and factors controlling response of metals to external forces. Some early returns



**Getting closeups** of a crystal lattice is a job for an electron microscope. When coupled with x-ray diffraction and induction-furnace techniques, the instrument reveals how small changes in a metal's structure affect tensile and yield strengths, ductility, hardness, and other properties.



**Transparent tape**, removed from a stressed aluminum surface, shows gas-bubble imprints. The horizontal line is powdered metal that was extruded from the fatigue crack. Gas often bubbles off when a fatigue crack first opens.

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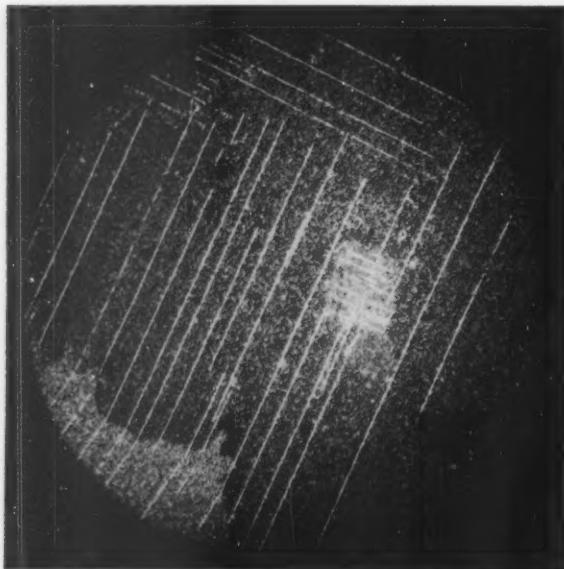
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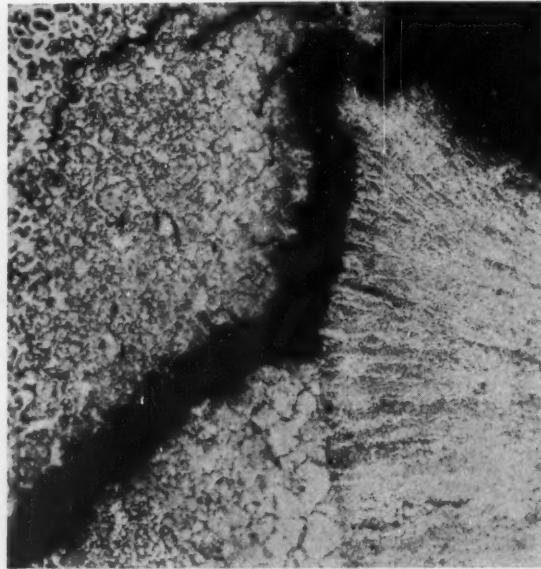
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**Reversed torsional loading** bends slip bands (white lines) in different directions in each grain. The small grain near the center is completely surrounded by a grain of different orientation. Surface photographed is that of an aluminum alloy test specimen.



**Fracture of a steel bar**, formerly employed by the St. Lawrence Seaway to hold a lock gate in position, occurred because of stress from dimensional changes during cold weather. The metal was embrittled by heat of a heavy weld. Structural change (right) shows in metal adjacent to weld.

are in, especially on the metal fatigue problem.

#### Fatigue Cracks

Metal fatigue is the most common cause of mechanical failure, and designers give it considerable attention. But behavior of components subjected to fluctuating or repeated stresses still cannot be predicted with complete accuracy.

Authorities agree that fatigue cracks generally start on existing slip bands within the grains of a metal. In the NBS study, each grain acted independently of its neighbors. Neither grain boundaries nor interaction between neighboring grains were found to promote cracking. Principal factors turned up were the amount and pattern of shear stresses on the plane of easy slip. Most fatigue cracks start at the edges of a metal specimen because of the stress pattern—not because the edges are saddled with a lower fatigue strength.

Chemical reactions at metal surfaces are known to have an important influence on fatigue behavior. NBS demonstrates such reactions with a simple test. When a transparent tape is applied to a metallic surface, bubbles form under the tape at the same time that fatigue

cracks appear. The bubbles (a gas liberated by surface reactions) are expected to provide a useful means of studying such surface effects.

#### Residual and Textural Stresses

By using x-ray diffraction techniques to determine stresses within a metal's structure, NBS researchers have found that residual stresses resulting from plastic deformation also exist in undistorted metals. But in the latter, the stresses are balanced by oppositely directed stresses, either in distorted crystals adjacent to grain boundaries or in slip bands.

Textural stresses arise because of unequal thermal contraction of different phases of a multiphase alloy. NBS research indicates a completely stress-free condition cannot be obtained in alloys by any technique yet developed. But while textural stresses are one cause of metal fatigue that cannot be eliminated, they can be minimized and work is progressing along these lines.

#### High-Strength Alloys

Fatigue strengths of most ferrous metals are roughly proportional to their tensile strengths. But when steels are heat treated to high hardness, the proportionality disappears; for example, when tensile strength

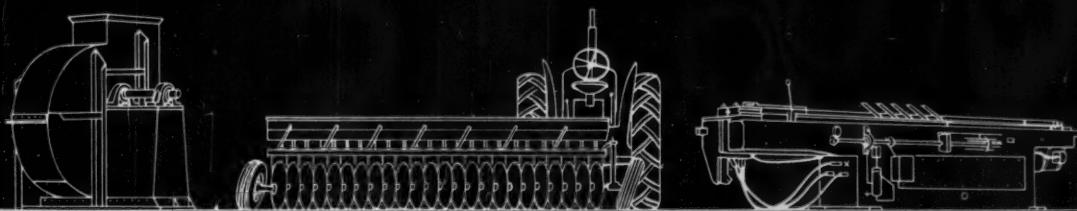
is raised above about 200,000 psi, fatigue strength is not further improved.

Retained austenite (the face-centered cubic form of iron that exists in steel at high temperatures) has been proved by the Bureau to be the factor that limits fatigue strength. NBS researchers now believe that with more suitable heat treatment, retained austenite can be eliminated in most carbon and low-alloy steels.

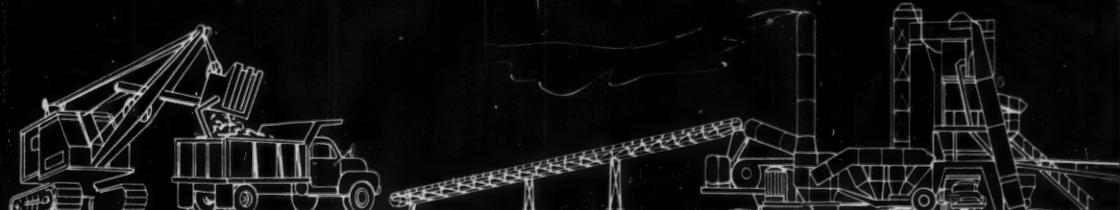
To demonstrate the point, the Bureau has developed an exceptional steel for the Navy. It boasts high hardenability, sufficient ductility for structural uses, and a fatigue strength proportional to tensile strength for tensile strengths up to 300,000 psi.

Additional research is being conducted on a host of subjects pertaining to metal failure. Studies of the effects of high temperatures, for example, are leading to a better understanding of creep. In other programs, an extensive study of steel plates that had fractured during service on merchant ships has led to more rigid specifications for ship plate. Similar work for the Civil Aeronautics Board and defense agencies has a bearing on the safety of transport aircraft.

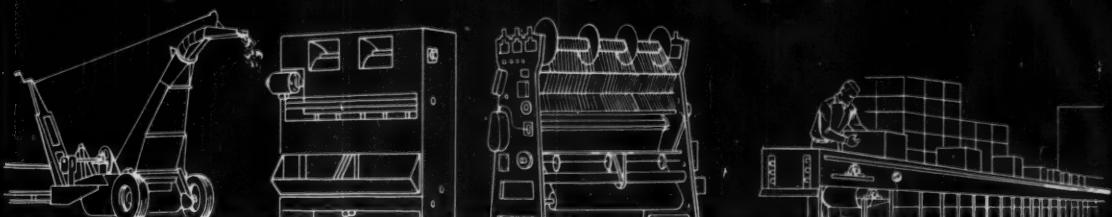
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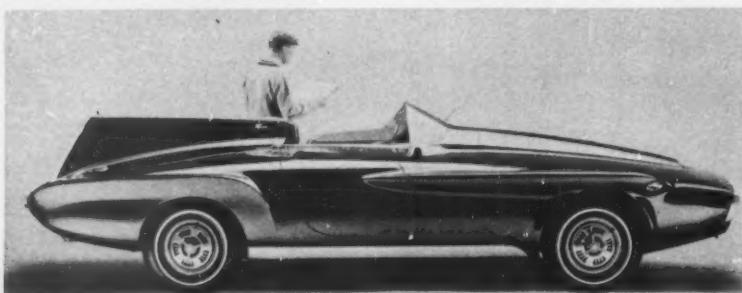


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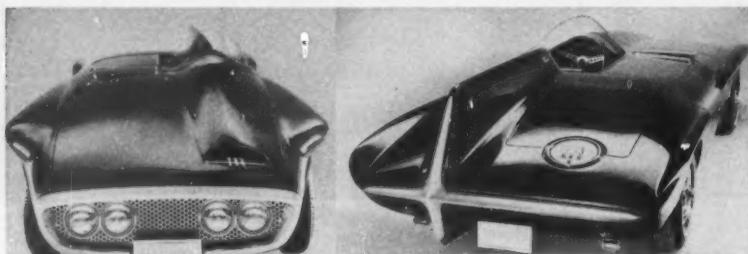
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## This Is a Plymouth?



**A Fin on wheels,** the XNR is a new Plymouth "idea" car, developed by and named for Virgil M. Exner, vice president and director of styling for Chrysler Corp. Drastic departure from conventional styling is the XNR's off-center streamlining, which centers around the driver. Since the car is only waist high, the driver's protruding head presents some wind resistance; to compensate, an air-scoop and a stabilizer follow a line that includes the driver. Basically a one-man vehicle, the XNR does have an extra seat—four inches lower than the driver's to make sure the passenger keeps his head down. Front bumper of the car is also the frame for the grille; rear bumper is X-shaped and follows the lines of the stabilizer edge and the rear edge of the car itself. Dimensions are 195.2 in. long and 42.9 in. at the top of the rear stabilizer. Body of the XNR is by Ghia; its engine is a standard Chrysler six-cylinder model.



## Public Must Know What's What In Science and Engineering

### GE Lab Head Proposes an Academy of Engineering

SCHENECTADY, N. Y.—Direct application of scientific discoveries in recent years has produced an effect that may prove injurious, not only to engineering, but to science itself, according to Dr. J. Herbert Hollomon, head of the General Engineering Laboratory of General Electric Co.

Dr. Hollomon fears that technological advances in the U. S. may be hampered by a "popular misconception of the proper roles of science and engineering." Engineering, which Dr. Hollomon calls the "application of scientific knowledge for the purpose of filling human needs," has come to be regarded as

less important, less challenging than science and has consequently lost favor as a choice of career. At the same time, the goal of science—basic understanding and knowledge—has been obscured by the demand for practical applications.

A National Academy of Engineering, similar to the National Academy of Sciences, would help establish the importance of engineers and engineering to our country, says Dr. Hollomon, and he urges that Congress set up such an academy. Its function would be to investigate, examine, experiment, and report on any subject of engineering called for by any department of the government.

Future developments will demand technological growth, the "imaginative vision" for which can be provided by a National Academy of Engineering, according to Dr. Hollomon.

## Scientists Uncover Clue To Hydrogen Embrittlement

MENLO PARK, CALIF.—Fundamental research at Stanford Research Institute has yielded clues which may solve the problem of hydrogen embrittlement in steel.

Exploring the chemical reactions of atoms with solids, SRI scientists have probed the reaction of hydrogen atoms with graphite. A radio-frequency discharge is used to produce hydrogen atoms from hydrogen molecules in a glass tube several inches in diameter and several feet long. At pressures of about 20 microns, atoms travel down the tube and impinge on a graphite disc.



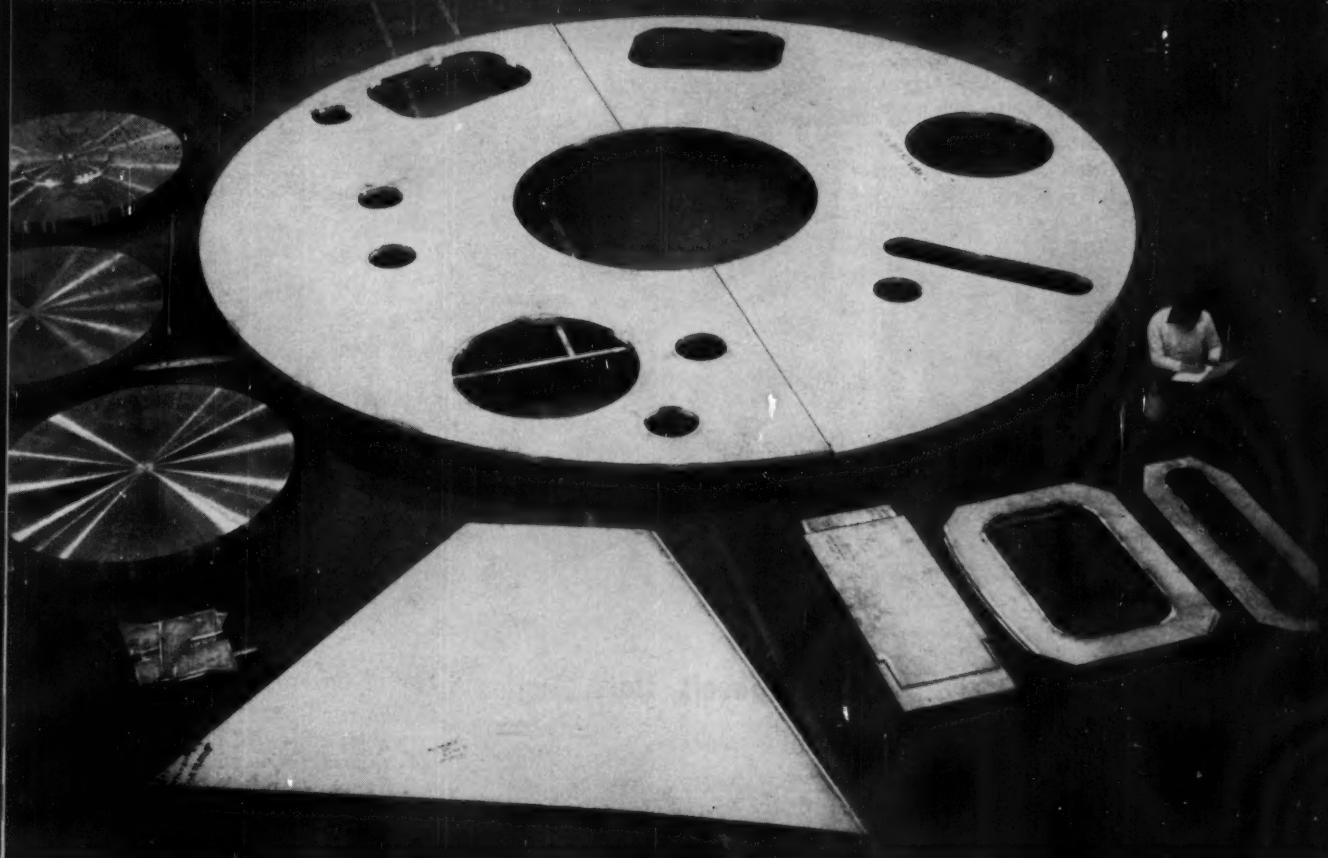
The reaction products—hydrocarbons such as methane, acetylene, and higher paraffins—have led to SRI's hypothesis of the mechanism of hydrogen embrittlement.

Hydrogen molecules are dissociated into atoms during absorption. These atoms are small enough to migrate into the steel. Since it has been shown that hydrogen atoms react with carbon at room temperature, SRI feels it is reasonable to assume that such reaction also takes place in steel. Thus, methane, and possibly other hydrocarbons, are formed in the interstitial spaces of the steel. The molecules are too big to diffuse further, so they must remain in place, creating tremendous pressures. SRI believes these pressures, combined with the removal of carbon atoms from the lattice, cause embrittlement.

Although hydrocarbons previously have been detected in steel subjected to high-temperature hydrogen embrittlement, this research at SRI indicates that reaction between carbon and atomic hydrogen proceeds at a measurable rate even at room temperature.

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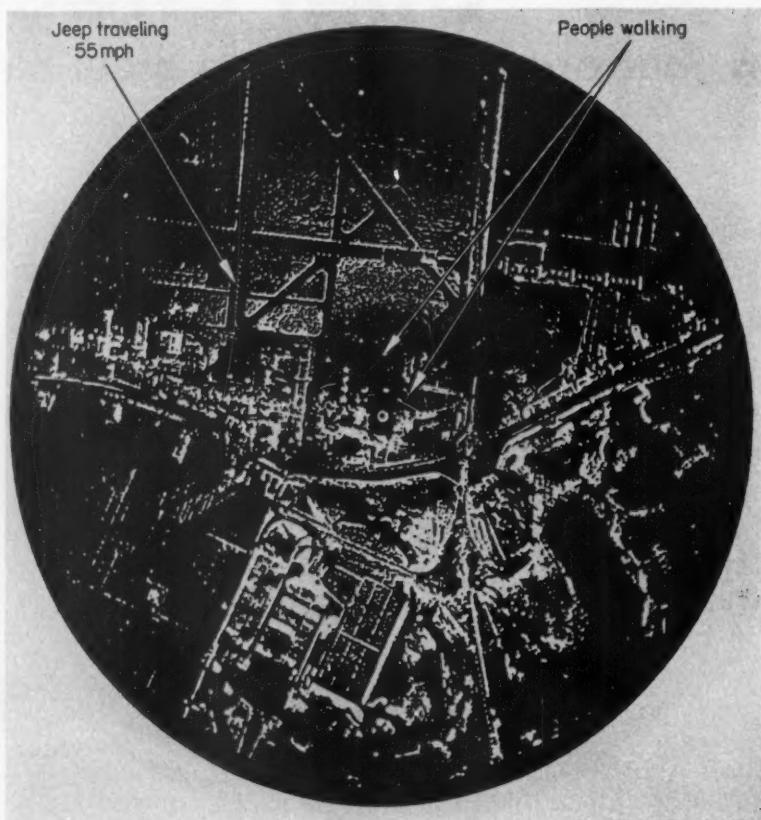
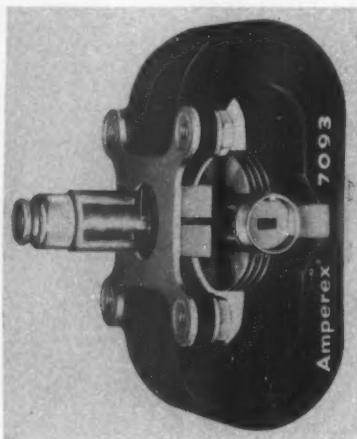
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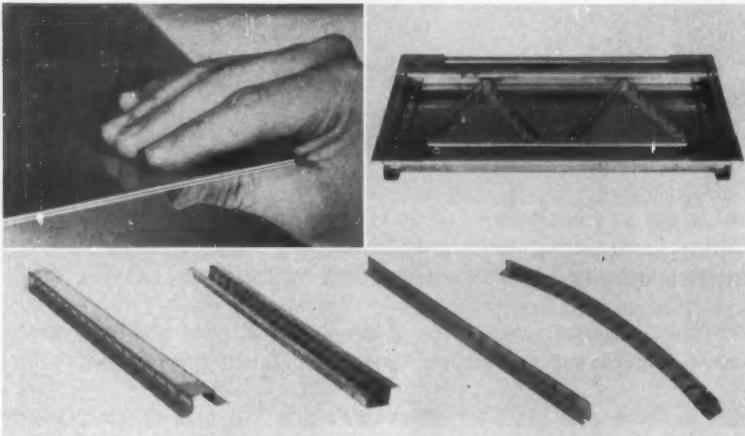
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## Short-Pulse Radar Gives Fine-Grained Detail

New magnetron designed for short-range radar puts out short enough pulses (0.02 μ sec) to track people. With it, five-mile radars will have a 4.5-yd resolution and a minimum detection range of a few yards. Such radars will be extremely useful in improving safety at airports, says Amperex Electronic Corp., Hicksville, N. Y., the developer. Military uses such as radar-mapping systems and bad weather reconnaissance are obvious. Radarscope photo of Schipol Airport, Netherlands, was obtained with a system using the new magnetron.



## Wide-Band Vibration Damper in Sheets, Hats, Angles



**Response of structures** to wide-band noise and high-frequency vibration is closely controlled by a new damping material. Dyna-damp, developed by Lord Mfg. Co., Erie, Pa., limits resonant amplification to 5:1 maximum over a wide frequency range (100:1 amplifications are common in undamped aircraft structures). Made up of metal sheets bonded together by a new elastomer (the vibration absorber), the material can be used at temperatures between -65 and 250 F. Temperature sensitivity at ends of the range is not a limitation, says a Lord spokesman. Available in laminated panels, hat or angle sections, Dyna-damp can be fastened to almost any structure to substantially reduce vibration.

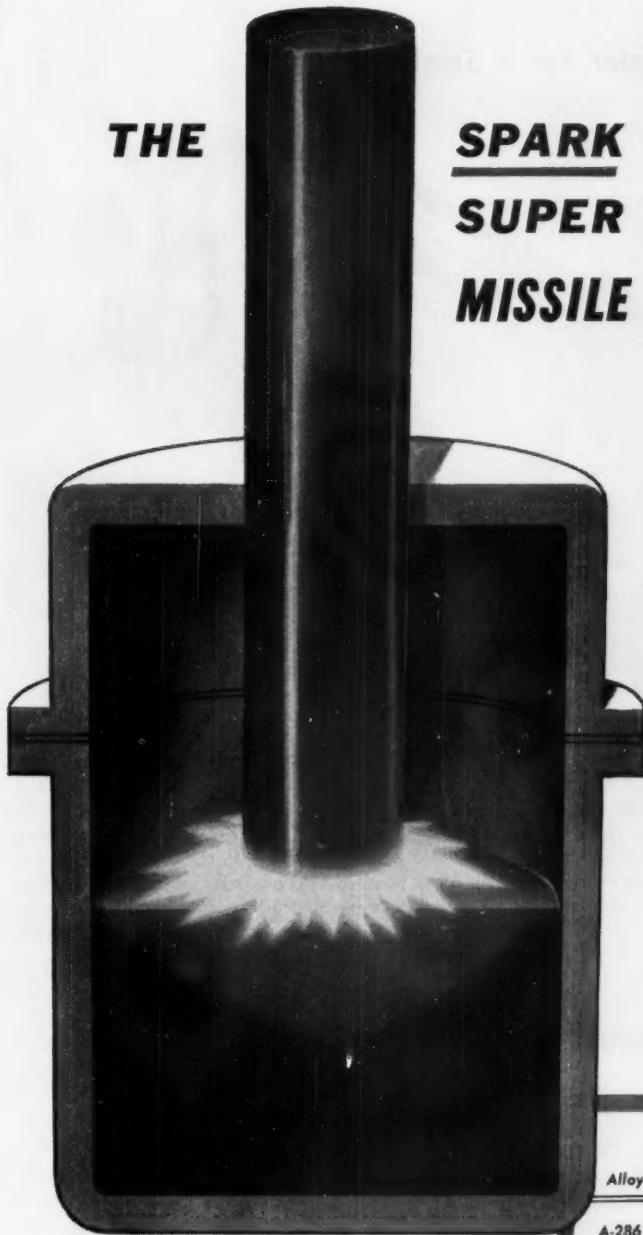
## Pay of Government Engineers Is Due for Upgrading

Civil Service Commission Head Recommends Flexible Salary Plan

WASHINGTON — Salaries of government-employed engineers and scientists may soon be raised to the top levels of their grades to bring compensation more nearly in line with that of industry. Salaries were upped in this manner prior to the 1958 Salary Increase Act, but the act automatically revised the top step of the grade arrangement. Several agencies, unable to hire and keep enough engineers and scientists, have appealed to the Civil Service Commission to again increase starting rates to the top increment.

Only 31 per cent of engineers offered federal jobs in 1959 accepted them, compared with 37 per cent the year before. In contrast, the acceptance rate in industry was 43 per cent in 1959. More than half of the people who turned down

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Fine electric furnace steel electrodes are remelted vertically in a water cooled copper ingot mold under a vacuum of 5 to 50 microns. The result? Midvac Steels to meet the most critical design applications of today's missile and aircraft requirements. Steels made by a process that makes super alloys even better. Insures increased tensile and impact properties, improved stress rupture strength at elevated temperatures and longer fatigue life.

With the Midvac Process of consumable electrode vacuum melting standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Midvac Steels are offered in many super alloys (some are shown in the table below) in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, turbine components, air craft landing gear parts and other products requiring properties beyond the capabilities of conventional steels.

Alloy	Melting Process	Yield Strength .2	Ultimate Tensile Strength	Percent Elongation	Percent Reduction of Area
A-286	Air Melt	99,000 psi.	132,300 psi.	9.0%	14.7%
	Midvac	117,000 psi.	150,500 psi.	21.3%	33.8%
Gannaloy	Air Melt	112,000	159,900	13.0%	21.0%
	Midvac	142,600	177,250	18.0%	31.6%
D6A-C	Air Melt	234,800	281,000	4.9%	20.6%
	Midvac	256,700	294,250	9.6%	28.4%
Tricent	Air Melt	238,600	284,500	6.1%	19.7%
	Midvac	254,300	291,600	10.3%	25.6%

Properties shown are averages of 25 heats

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# *Midvac Steels*



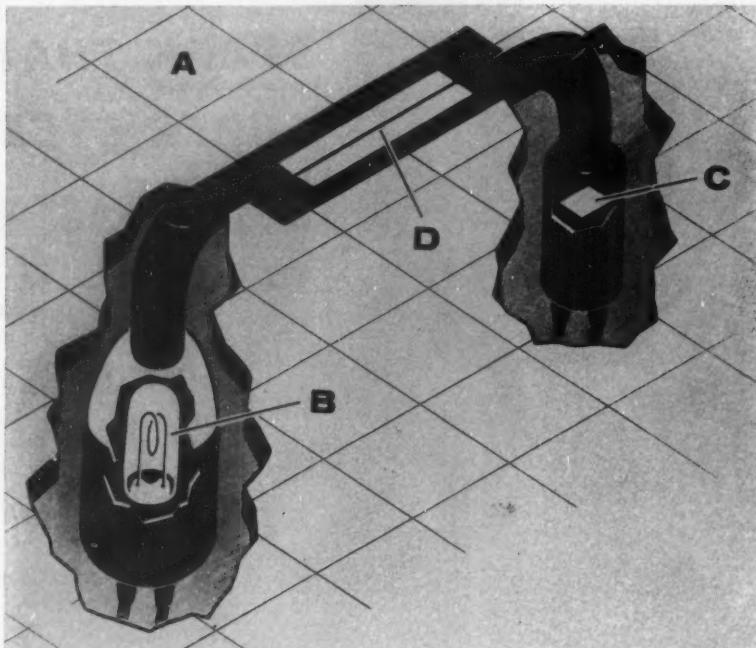
federal jobs did so because of salary.

Private industry paid June, 1958, graduates \$5600 to \$5700 to start; in 1959 the rate had gone up to \$5800 to \$6200, and it is expected to increase an additional 2 to 4 per cent in 1960. The government was offering \$4490 for "average" graduates and \$5430 for "superior" graduates in both 1958 and 1959. This year—even if starting rates are boosted to the maximum \$4940 and \$5880—Uncle Sam still has less cash to offer.

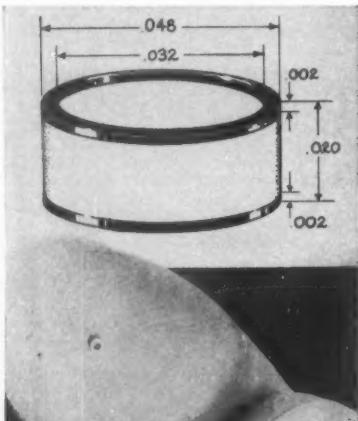
Salt in the salary wound is added by the lack of adjustment between blue-collar and white-collar compensation. For instance, an apprentice in the Naval Ordnance Plant, Charleston, W. Va., starts at \$4740 a year; an engineer with a B.S. degree can work at the same plant for \$4490 (\$5430 if he had superior grades).

Solution to the federal engineering employment problem suggested by CSC Chairman Roger W. Jones is adoption of a flexible pay plan for classified employees. This, says Mr. Jones, will enable the government to "adjust salaries to solve pay problems and serve the legitimate needs of management."

## Ice Detector for a Small Plane



**Wing ice**—extra hazardous for lightplanes—is signaled by a new small-plane safety device. The simple detector, developed by Armour Research Foundation, Illinois Institute of Technology, works on light-refraction principles to warn the pilot as soon as ice starts forming. It's made up of two parallel translucent plastic rods, silvered for greater efficiency, mounted a fraction of an inch apart on the plane's wing (A). Light (B) is beamed into one rod; photoelectric cell (C) monitors the other. When ice forms between the two rods (D), light refracts out of the first rod, through the ice, and into the second rod to activate the cell.



## Tunnel Diode Gets a House

Metal housings with diameters ranging from 0.045 to 0.050 in. have now been designed for tunnel diodes. According to Mitronics Inc., Hillside, N. J., aluminum-oxide housings are metallized on both ends with moly manganese and are then nickel plated, making them suitable for silver-alloy brazing. If necessary, the part can be hermetically sealed.

## High-Strength Steel Resists Notch Sensitivity

### Weldable Rocket-Motor Alloy Looks for New Uses

BRIDGEVILLE, Pa. — A newly developed steel is giving added reliability to rocket-motor cases. Developed especially for this application, the steel shows essentially no susceptibility to notch sensitivity. In addition, it boasts yield strengths of 225,000-235,000 psi.

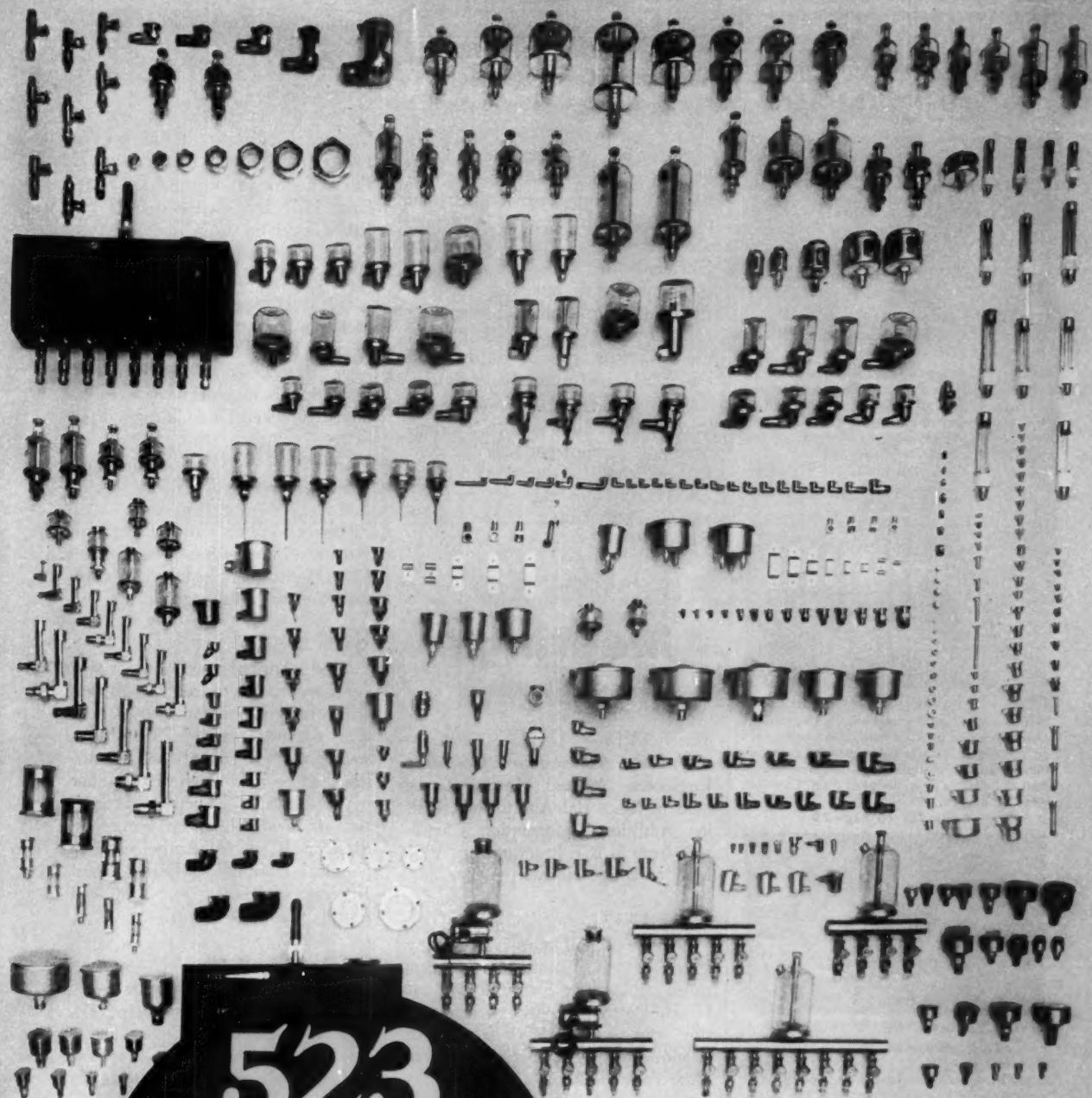
According to Universal Cyclops Steel Corp., the developers, Unimach UCX2 has excellent forming characteristics and good weld-

ability. In fact, UCS claims it's so easily fabricated that it may actually decrease production costs of high-performance rocket cases. The combination of high strength and fabrication ease has led the company to start searching for other applications.

The steel is basically an AISI 4100 series steel, modified by the addition of cobalt as an alloying agent.

### Typical Properties of Unimach UCX2 Sheet

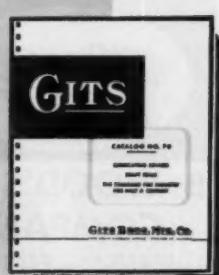
Sheet Thickness (in.)	Tempering Temperature (°F)	Hardness (Rockwell C)	Ultimate Strength (psi)	Yield Strength (psi)	Fracture Strength (psi)
0.070 in., notched	400	53	308,000	306,000	319,000
	1000	44	238,000	237,000	249,000
0.070 in., unnotched	400	53	307,000	235,000	341,000
	1000	44	205,000	188,000	245,000
0.125 in., notched	400	54	307,000	306,000	329,000
	1000	44	237,000	237,000	246,000
0.125 in., unnotched	400	53	295,000	242,000	351,000
	1000	44	206,000	193,000	263,000



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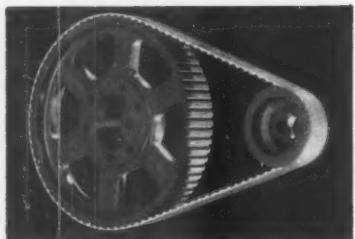


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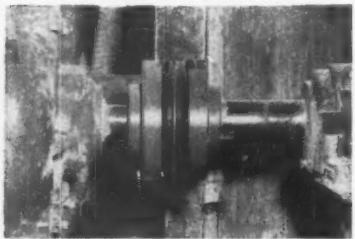
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Circle 420 on Page 19



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Wood's Sure-Flex Couplings absorb 5 to 15 times more shock and vibration than other leading flexible couplings... swallow all types and combinations of angular and parallel misalignment, endfloat. Simple, no wear, no lubrication. Low cost. Write for Bulletin 5103.

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### ENGINEERING NEWS

#### Automation Conference Slated For Purdue University in April

LAFAYETTE, IND.—The Fourth Conference on Manufacturing Automation, presenting a panel discussion plus 17 individual papers, will take place April 11, 12, and 13 at Purdue University. Topics will include costs, analysis of processes and procurement of machines, automating assembly, packaging, handling parts, use of various types of controls, and a look into the future of automation.

The conference is sponsored by Purdue and Automation; information is available from K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind., or Automation, Penton Bldg., Cleveland 13, Ohio.

quarters, 485 Lexington Ave., New York 17, N. Y.

#### March 23-25—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Carter Hotel, Cleveland. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

#### March 27-31—

Scientific Apparatus Makers Association. Annual Meeting to be held at Boca Raton Hotel & Club, Boca Raton, Fla. Additional information is available from SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

#### March 29—

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

#### March 29-31—

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sherman, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

#### March 31-April 1—

American Society of Mechanical Engineers, Textile Engineering Div. Textile Engineering Conference to be held at North Carolina State College, Raleigh, N. C. Further information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

#### April 3-6—

National Screw Machine Products Association. Annual Meeting to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from association headquarters, 2860 E. 130th St., Cleveland 20, Ohio.

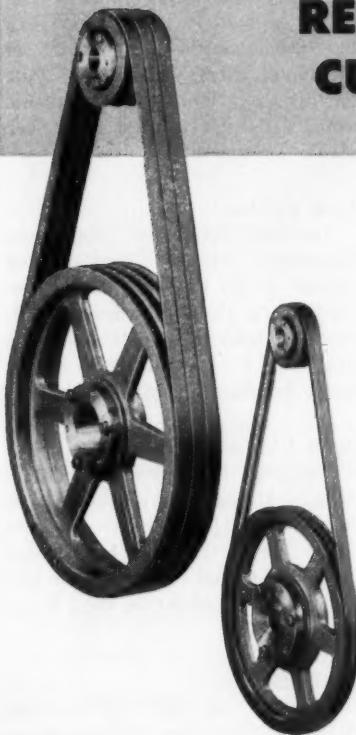
#### April 3-8—

Nuclear Congress, to be held in the New York Coliseum, consists of the 6th Nuclear Engineering and

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## ENGINEERING NEWS

Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition. Congress is sponsored by 28 engineering, scientific, management, and technical organizations. Further information is available from 1960 Nuclear Congress, 33 W. 39th St., New York 18, N. Y.

### April 4-7—

American Management Association. 29th National Packaging Exposition to be held at Convention Hall, Atlantic City, N. J. The National Packaging Conference also will be held at Convention Hall, April 4-6. Further information is available from AMA, 1515 Broadway, New York 36, N. Y.

### April 5-8—

Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at the Hotel Commodore, New York. Further information can be obtained from the society, 485 Lexington Ave., New York 17, N. Y.

### April 6-9—

Society of the Plastics Industry. Annual Conference of the Western Section to be held at the Riviera Hotel, Palm Springs, Calif. Additional information can be obtained

from C. L. Wurdeman, Rezolin Inc., 1651 18th St., Santa Monica, Calif.

### April 7-8—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

### April 11-13—

Fourth Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and Automation magazine. Further information can be obtained from K. E. Glancy, Div. of Adult Education, Purdue University.

### April 12-13—

Institute of Radio Engineers. 14th Annual Spring Technical Meeting to be held in conjunction with the American Rocket Society at the Hotel Alms, Cincinnati, Ohio. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

### April 19-21—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Netherland-Hilton Hotel, Cincinnati. Additional information is available from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

### April 19-21—

National Microfilm Association. Ninth Annual Convention to be held at the Hotel Sheraton-Hilton, New York. Further information can be obtained from C. Peter McCollough, Haloid Xerox Inc., Rochester 3, N. Y.

### April 20-22—

Institute of the Aeronautical Sciences. National Symposium on Manned Space Stations to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

### April 21-28—

American Society of Tool and Manufacturing Engineers. Tool



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2-333	5427-36	-333			546806	570207
2-334	5427-37	-334			546807	570208
2-335	5427-38	-335	335	AN6227B-8	546808	570209
2-336	5427-39	-336	-336	AN6227B-9	546809	570210
2-337	5427-40	-337	-337	AN6227B-10	546810	570211
2-338	5427-41	-338	-338	AN6227B-11	546811	570212
2-339	5427-42	-339	-339	AN6227B-12	546812	570213
2-340	5427-43	-340	-340	AN6227B-13	546813	570214
2-341	5427-44	-341	342	AN6227B-14	546814	570215
2-342	5427-45	-342	343	AN6227B-15	546815	570216
2-343	5427-46	-343	-343	AN6227B-16	546816	570217
2-344	5427-47	-344	-344	AN6227B-17	546817	570218
2-345	5427-48	-345	-345	AN6227B-18	546818	570219
2-346	5427-49	-346	-346	AN6227B-19	546819	570220
2-347	5427-50	-347	-347	AN6227B-20	546820	570221
2-348	5427-51	-348	-348	AN6227B-21	546821	570222
2-349	5427-52	-349	-349	AN6227B-22	546822	570223
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# ALLEN



**Allenpoint's deep, full-circle  
bite assures tremendous  
resistance to removal torque!  
Stays tighter longer!**

When you need a set screw that you can depend on to stay tight under heavy strain and vibrations, specify ALLENPOINT. Here's why you can always depend on ALLENPOINT: proper design of the cup diameter results in a rugged grip that makes the full-circle pattern you see here... deep, strong, clean sockets allow full wrenching leverage... and uniform Class 3A threads assure a tight friction lock over the entire length of Allenpoint Set Screws.



Ask your ALLEN Distributor for samples and full engineering details—he's always ready, willing, and able to give you prompt, practical service!



**ALLEN MANUFACTURING COMPANY**  
HARTFORD 1, CONNECTICUT, U.S.A.

## ENGINEERING NEWS

Show to be held in the Artillery Armory, Detroit. Further information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

### April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS, 33 W. 39th St., New York 18, N. Y.

### April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton-Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

### May 3-5—

National Association of Relay Manufacturers. Eighth Annual Conference on Electromagnetic Relays to be held at Oklahoma State University, Stillwater, Okla. Additional information is available from Prof. Charles F. Cameron, P. O. Box 6, Stillwater, Okla.

### May 9-12—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Civic Auditorium and Brooks Hall, San Francisco. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

### May 9-13—

Society of Photographic Scientists and Engineers. Annual Conference to be held at the Miamaran Hotel, Los Angeles. Additional information can be obtained from the society, Box 1609 Main Post Office, Washington, D. C.

### May 9-13—

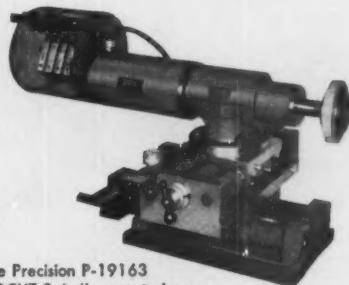
American Society for Metals. Second Southwestern Metal Exposition and Congress to be held at the Sheraton-Dallas Hotel and State Fair Park, Dallas. Additional information is available from ASM, Metals Park, Novelty, Ohio.

# For Fast Removal Of Tough Metals Specify ELECTROLYTIC GRINDING

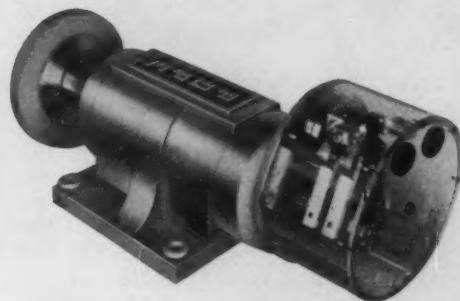
## For Electrolytic Grinding Specify POPE PRECISION "ANOCUT" SPINDLES with total eccentricity of shaft less than fifty millionths (.000050")

Pope "Anocut" Spindles are available for 50 to 3000 amp. operation, motorized or belt driven with wheels up to 28" dia. They are equipped with built-in insulation and a new Pope rugged fork type, cool operating brush assembly for transmitting low voltage, high amperage current to the wheel.

To get the most production out of electrolytic grinding, you need Pope designed, precision built electrolytic grinding spindles. Let us have your specifications for quotations.



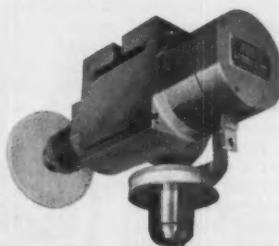
Pope Precision P-19163  
ANOCUT Spindle mounted on  
Pope heavy duty universal  
slide with indicators for measuring  
feed in ten-thousandths.



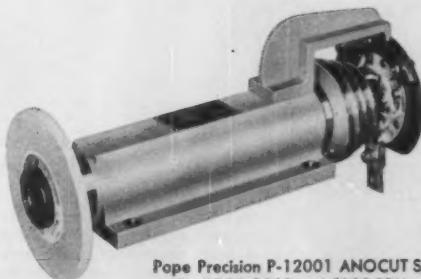
Pope Precision P-19162 ANOCUT Spindle;  
1 to 20 HP, 1800 RPM.



Pope Precision P-3007 ANOCUT Spindle;  
— 10,000 RPM.



Pope Precision P-6651-XG-S4 ANOCUT  
Tilting Head for attaching to Cincinnati #2  
Tool and Cutter Grinder.



Pope Precision P-12001 ANOCUT Spindle  
— for 2000, 3000 and 5000 RPM.

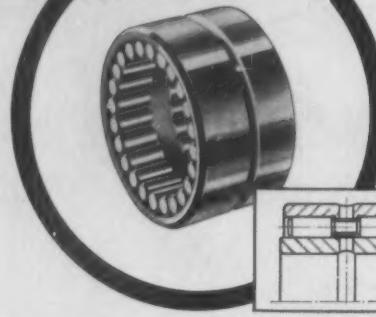
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POPE MACHINERY CORPORATION • 261 RIVER STREET • HAVERHILL, MASS.

ENGINEERS AND BUILDS STANDARD AND SPECIAL  
PRECISION ANTI-FRICTION BEARING SPINDLES  
FOR EVERY PURPOSE

Established 1920

**BEARING TIPS**  
by **McGILL**



# GUIDEROL®

## BEARINGS SOLVE SPECIFIC DESIGN PROBLEMS

with high capacity in small radial space, precision efficiency and "sealed in" lubrication

McGILL GUIDEROL Bearings combine the higher inherent capacity of full complement needle roller bearings with "center-guided" roller control. GUIDEROL bearing construction encourages space and cost saving design of shaft and housing components. For a given shaft of 1" a GUIDEROL bearing provides 23% more capacity in  $\frac{3}{8}$ " less housing space than a typical cylindrical roller bearing. A comparable ball bearing uses almost an inch

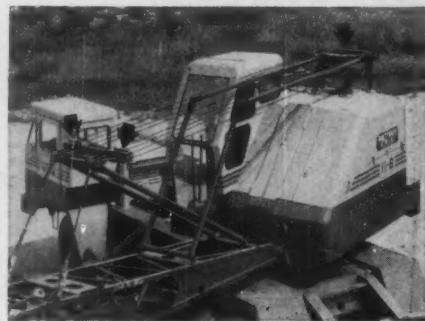
larger OD for 1500% less capacity.

Use the Sealed SGR series to protect GUIDEROL bearing efficiency when contamination exists. Avoid frequent re-lubrications.

GUIDEROL bearings are available with or without separable inner ring. Shaft sizes:  $\frac{5}{8}$ " to  $9\frac{1}{4}$ ". Capacities to 128,670 lbs. (at 100 RPM).

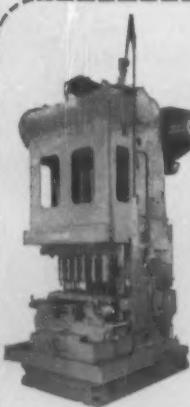
### Bucyrus-Erie Cuts Lubrication from Daily to Monthly with Sealed Guiderol Bearings

BUCYRUS-ERIE CO. has incorporated the advantages of GUIDEROL GR-28RSS, sealed bearings in their 11-B TRANSIT CRANE-EXCAVATOR. The bearings serve as mountings for sheaves in the 11-B boom suspension which is a wire rope system running from a powered cable drum over the sheaves. The GUIDEROL bearings decrease friction and provide a jerk-free lowering and raising of the boom. In addition, they have increased periods between lubrication from once a day to once a month under normal operation. BUCYRUS-ERIE also cites ease of assembly due to holding to close manufacturing tolerances as an additional benefit. Loads on these bearings are approximately 10,000 lbs.; speeds — 56 RPM. Bearings are used in both horizontal and vertical mountings.



### Moline Tool Co. Get High Radial Load in Minimum Space

Each of the six spindles of the MOLINE Model 116U hydraulic rail feed, universal joint type drilling machine has two GUIDEROL upper bearings and two GUIDEROL lower bearings. The GUIDEROL bearings replaced bronze sleeve bearings used in previous design of the machine. The GUIDEROL bearings were selected for their ability to get the highest possible radial load in minimum space and still retain the advantages of a precision anti-friction bearing. Vertically mounted, the bearings are lubricated by drip feed oil from the upper drive unit. The unsealed GUIDEROL bearings with open ends permit a free flow and the roller retaining ring acts as an oil ring to pick up and distribute the lubricant.



### Guiderol® Bearings Take Heavy Loads of High Volume Hydraulic Pump Service.

GALION ALLSTEEL BODY COMPANY'S combination high volume roller bearing pump and spool valve has been developed to furnish the large volume of high pressure oil needed for fast dumping with Duo-scopic hoists. These pumps operate the hydraulic cylinders on the complete line of Galion trailer dump bodies. Four small GUIDEROL bearings easily accept loads of 3,500 pounds on the driving shaft and 4,500 pounds on the driven shaft. They provide maximum capacity in small radial space with a full complement of race width rollers. These center guided rollers help insure the precision performance required to increase pump capacity to 1,450 PSI at 1,000 RPM.



engineered electrical products

**McGILL**  
precision needle roller bearings

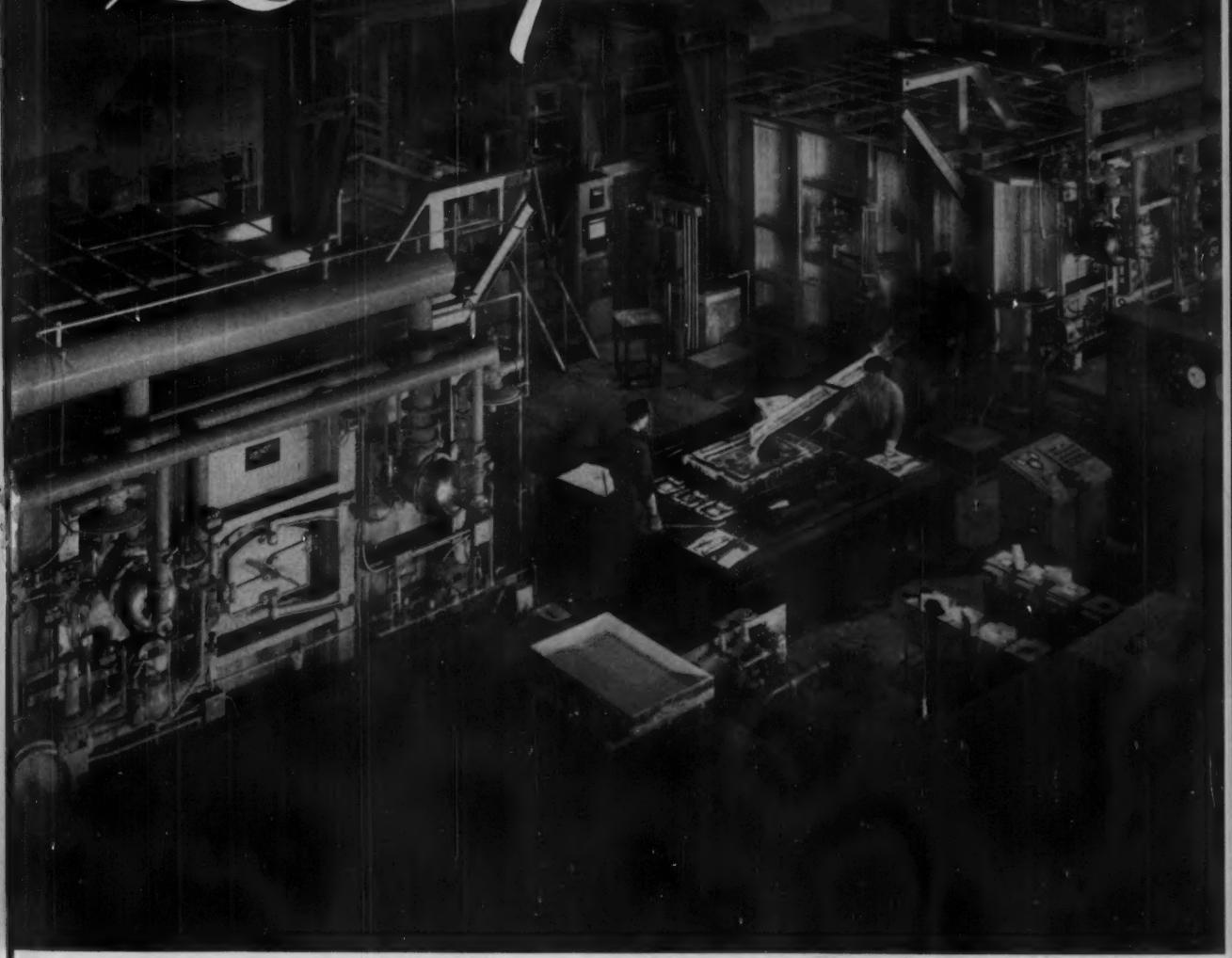
Send for Free Bearing Catalog No. 52A for complete Data.

**MULTIROL-GUIDEROL-CAMROL-CAGEROL**

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

**MODERN EQUIPMENT PRODUCES**

# *Quality Aluminum*



Inside QSM's new cast house the most advanced equipment and metallurgical techniques have been combined to produce aluminum alloy rolling ingots of exceptional quality.

For productive efficiency two custom-built Swindell-Dressler melting furnaces have been set up with two companion holding furnaces in tandem. Molten metal is transferred directly from melting to holding furnaces after the industry's most modern fluxing has been completed.

As a final assurance of top quality, the melt is held in a "tranquil bath" until filtered at a controlled rate through glass cloth screening into the molds.

The resulting ingots will meet QSM's exacting standards and insure you of quality aluminum sheet and coil.

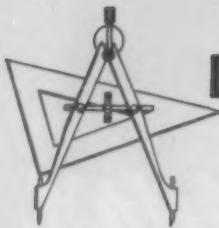


**QUAKER STATE METALS CO. • LANCASTER, PA.**

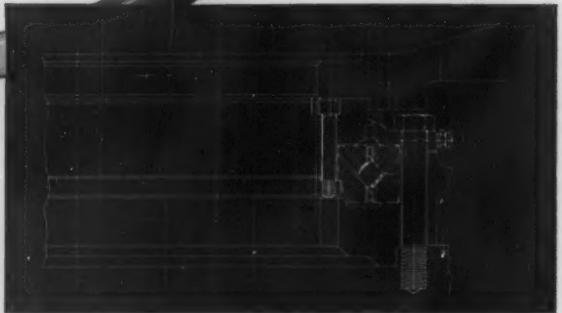
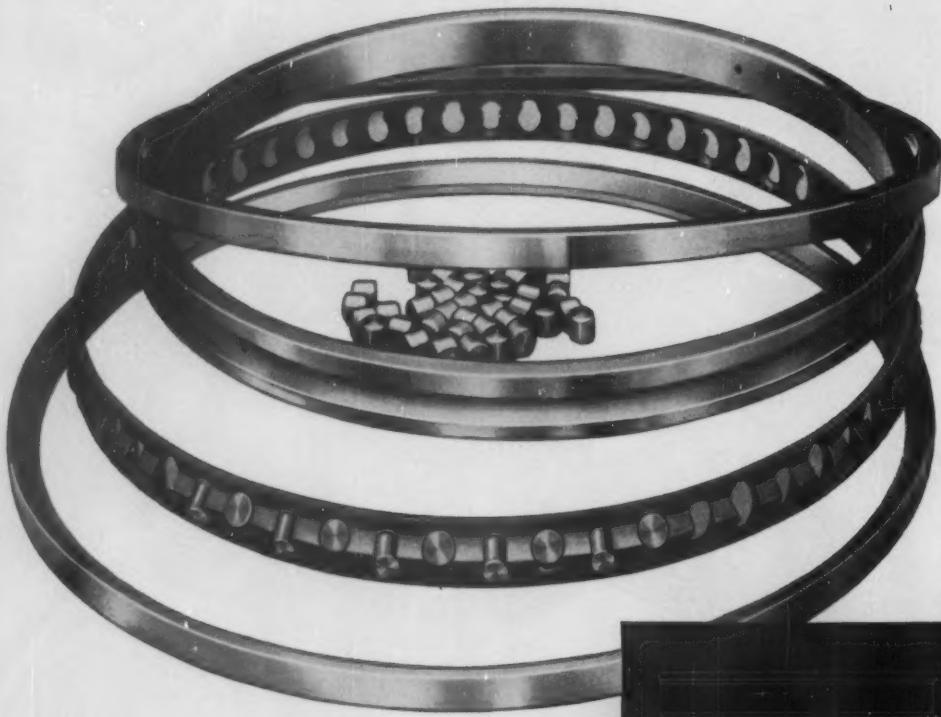
*A Division of HOWE SOUND COMPANY*

**Mill Producers of Aluminum Sheet and Coil**

*Circle 429 on Page 19*



# DESIGN YOUR PRODUCT TO PROVIDE Years of Accurate Bearing Performance With the MESSINGER "X" BEARING



**ENDURING ACCURACY**... revolving parts not deviating one thousandth of an inch after years of service... is one answer to the wide use of the patented "X" Bearing in a wide variety of applications... from work rolls to gun turrets to radar screens.

**VERSATILITY** is another reason why the "X" Bearing offers so many practical design advantages. It can carry the load in three directions—thrust either way and radial. Actually, it can be designed to take the place of four bearings—two thrust and two radial.

CONSIDER THE "X" BEARING on your next design problem. Standard sizes range upwards from 4.000" I.D., 6.250" O.D. and 1.125" in width. Write for complete information.

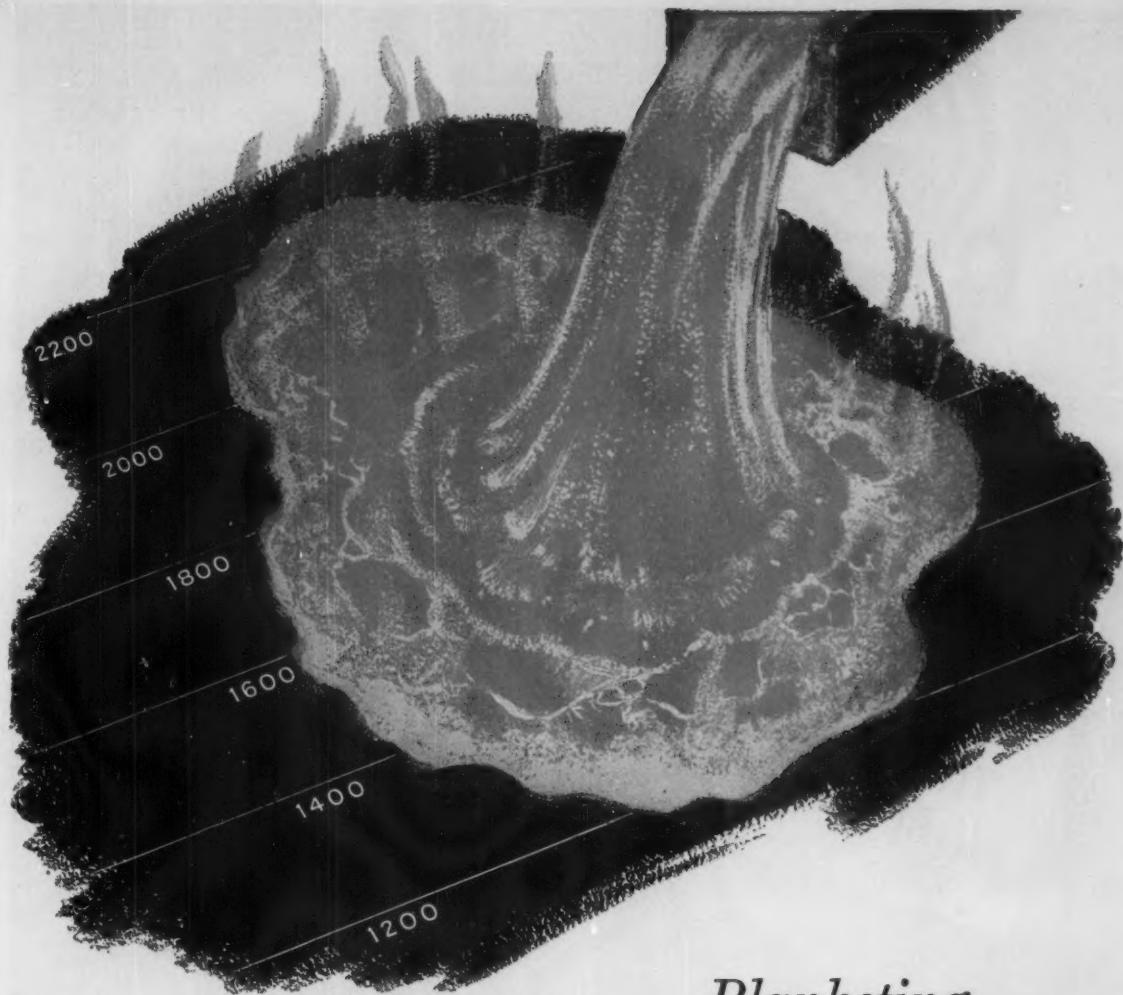
## TYPICAL APPLICATIONS...

Work, press, calender and suction rolls; boring mill tables; rock crushers; glass grinding machines; propellers; artillery and naval gun mounts; radar screens.

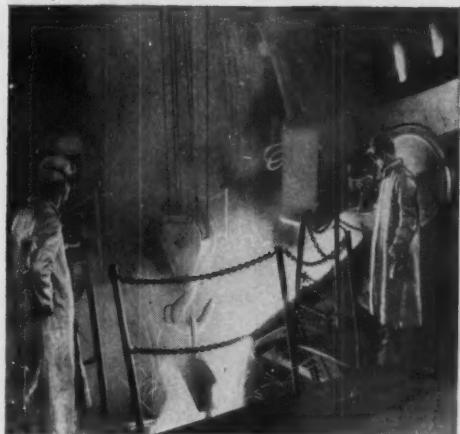
**MESSINGER**  **BEARINGS, Inc.**  
ROLLER AND BALL BEARINGS FEATHERWEIGHT TO HEAVYWEIGHT

**D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.**

"Smoothing Industry's Pathway for Nearly Half a Century"



## *Blanketing the high temperature field*



Close control is exercised over every step in the production of HAYNES alloys. This electric arc furnace is part of the modern mill set-up maintained at HAYNES STELLITE.

A fairly ambitious claim! Yet we can prove that HAYNES alloys do exactly that . . . all the way up to 2000+ deg. F. Here's why. There are 12 HAYNES high-temperature alloys. Among them you will find the right combination of properties to handle any heat condition. For example, HASTELLOY alloy X has remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 is strong and resists stresses, oxidation, and carburization up to 2000 deg. F. HASTELLOY alloy R-235 is outstanding in the 1500 to 1750 deg. F. range. And this is only part of the story. All 12 HAYNES alloys are *production* alloys and are readily available. Some of them are vacuum melted; some air melted. Some are cast, some wrought, and some are produced in both forms. For the full story, write for literature.

**HAYNES**  
ALLOYS  
**HAYNES STELLITE COMPANY**  
Division of Union Carbide Corporation  
Kokomo, Indiana

**UNION  
CARBIDE**

The terms "Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



## Extruded section reduces material required 65% on this flash butt-welded missile part

By leaving 2/3 of the titanium required at the mill, dramatic savings were effected on this ram jet engine part used in the Bomarc.

Amweld quoted the job, suggesting a special extruded section shown here, and saved 19.8 lbs. of expensive titanium per ring. The flash butt-welded rings from extruded sections offered additional savings in machining time, since only a small amount of metal had to be removed.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and machining facilities, phone or write.



### GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."



THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

# Aetna

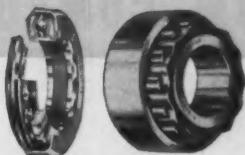
ROLLER BEARINGS

## True Crowned for 15% longer service life

Because each Aetna roller is *True Crowned* with a large radius, high stress points in the rollers are relieved—giving 15% longer bearing life. The crown radius is scientifically determined and varies with the roller size.

Aetna offers a wide range of self-contained *True Crowned* pure radial roller bearings in both custom and standard designs—also many special designs of both pure radial and pure thrust bearings for unusual applications.

For complete information on *True Crowned* Aetna Roller Bearings, call your Aetna representative listed in your classified telephone directory, or write for General Catalog and Engineering Manual.



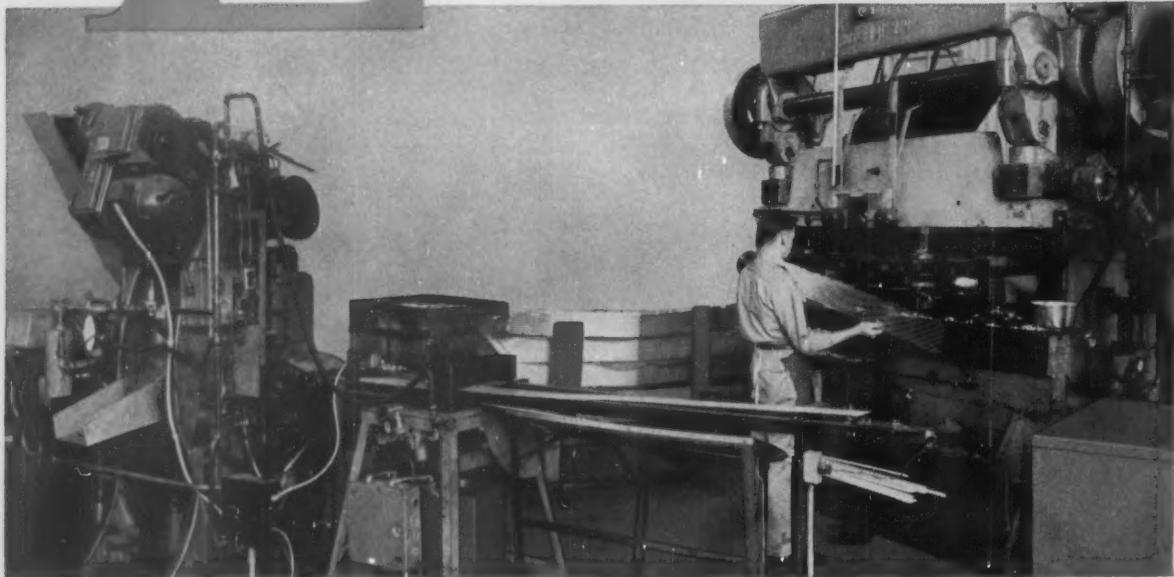
AETNA BALL AND ROLLER BEARING COMPANY  
DIVISION OF PARKERSBURG-AETNA CORPORATION

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and  
ECONOMY*



Efficient operation is the straight road to economy.  
And economy in *our* plant cuts *your* cost of production.

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At MIRRO, high-speed, automatic equipment lets us turn out *more* work with *less* work—and at a reject rate that's almost disappeared off the bottom of the chart. In the unit above, for example, feed, perforation, and cutoff operations are combined, to supply a single operator with prepared sheet for final forming. This is only one of many machines that make MIRRO a highly efficient and economical source for volume quantities of aluminum components.

Phone, wire, or write for more information about how we can help you do *your* job better, for less.



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## *Another **SPECIAL** application of Dayton Molded Rubber*



### **Clark simplifies axle machining with DAYTON SEMI-BONDED BUSHINGS**

When Dayton engineers applied the sound principles of "Engineering in Rubber" to designing a new steering axle pivot for Clark Fork Lift Trucks, the result was impressive. Not only was the performance of the bushing improved, but the new design enabled the entire axle casting to be simplified. This eliminated a separate bushing cap, an expensive boring operation, and saved assembly time before and after machining.

This is just one of the many ways in which Dayton serves industry by bonding rubber and

urethane to metal . . . a design approach that can solve your problems of vibration, shock and noise control . . . correct misalignment . . . simplify assembly . . . and reduce maintenance costs.

You too may be able to gain the advantage of improved performance and quality through "Engineering in Rubber." Fill out and mail the coupon below. It will bring you the prompt, efficient services of a molded products specialist to start you on the way to greater design flexibility and new savings.

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INDUSTRIAL DEPARTMENT

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Products Co.**

Melrose Park, Illinois

A Division of The Dayton Rubber Company

I have a design requirement and would like to discuss it with one of your sales engineers.

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**A rugged, dependable new shaft seal  
for a broad variety of applications**

### NATIONAL BUD\* SEALS

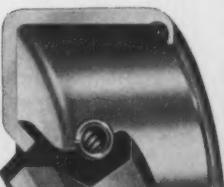
410,000 series



450,000 series



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**STANDARD LOW-COST UTILITY DESIGN**

New designs proven in 4 years  
of field application

Permanent bonded sealing lip,  
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Rugged case won't distort under  
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Sealing materials for temperatures  
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Operates in most oils or  
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National Seal engineers — who brought you Syntech® and Micro-Torc® — now offer a ruggedly simple new advance in precision shaft sealing — National BUD (Bonded Universal Design) Oil Seals.

BUD seals are designed for a broad variety of applications, including many where more complex

single-lip and double-lip designs were previously specified.

Full details and application engineering help on National BUD or other oil seals are available from your National Seal Division, Field Engineers. See the Yellow Pages under "Oil Seals" or write direct to Redwood City, Calif., home offices.

\*TRADEMARK NATIONAL SEAL

### NATIONAL SEAL

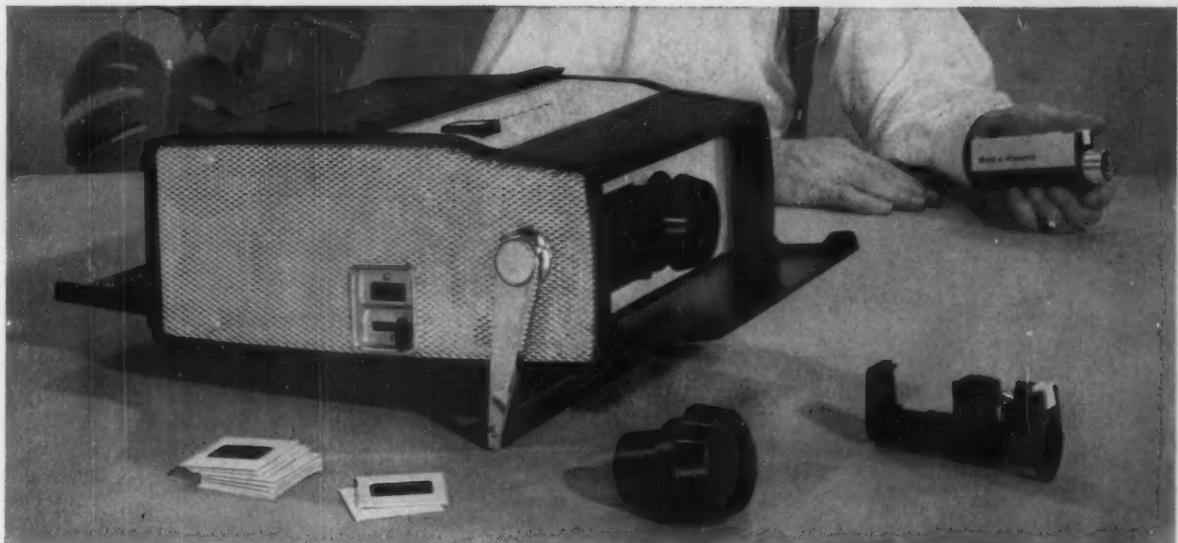
Division, Federal-Mogul-Bower Bearings, Inc.  
General Offices: Redwood City, California  
Plants: Van Wert, Ohio; Downey and Redwood City,  
California.



6071



## Handsome and Hardworking **Plexiglas...Implex**



for *Kelvinator* . . . PLEXIGLAS® acrylic plastic provides both beauty and strength for the handsome control panel on 1959 automatic clothes dryers. Pushbutton panel, backlit Cycle-Vu window panel and rotary dial behind window are all made of PLEXIGLAS.

for *Bell & Howell* . . . Tough new IMPLEX® high-impact acrylic plastic gives outstanding strength and resistance to staining in components of "Explorer" slide projectors. Lens barrel container, and housing of Point-A-Ray remote control unit, are molded of IMPLEX.

for you . . . PLEXIGLAS and IMPLEX may be just what you need to give your products added sales appeal. Our design staff and technical representatives will be glad to tell you about these Rohm & Haas molding materials.



Chemicals for Industry

**ROHM & HAAS  
COMPANY**

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: Rohm & Haas Co. of Canada, Ltd.,  
West Hill, Ontario

News! The best features of  
modern bearing design combined and refined in

# Spherical

## SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT

**B**IG, mirror-smooth convex rollers plus heavy, broad-shouldered inner race plus centrifugally-cast bronze, precision-machined retainers! Only from Link-Belt do you get ALL that is best in modern bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application.

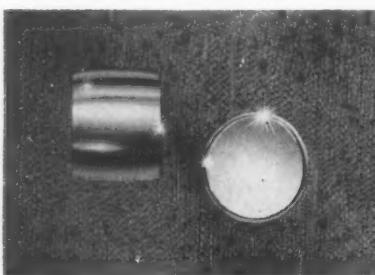
Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged-cartridge, cartridge, and take-up blocks.



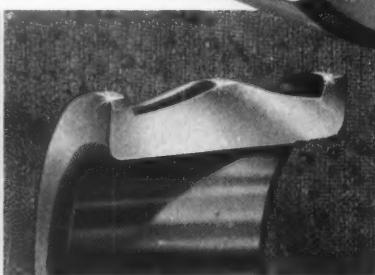
### MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices,  
Prudential Plaza, Chicago 1. Plants,  
Sales Offices and Distributors in All  
Principal Cities.

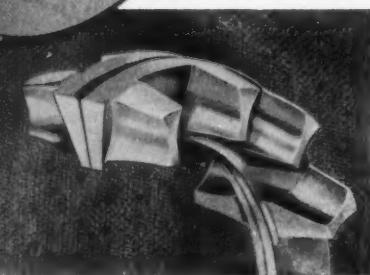
14-819-A



**BIG, HIGHEST-CAPACITY ROLLERS.** Each bearing has a maximum number of rollers—as large as possible, yet all components are in optimum balance.



**HIGH, HEAVY INNER RACE FLANGES** present convenient hold for assembly and removal of bearing without cutting away shaft, avoid any need to skimp on shaft shoulders.



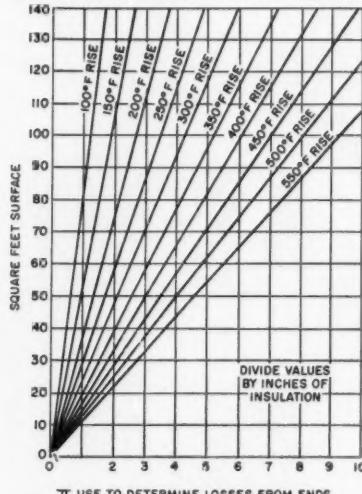
**PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS** have many times more support and ability to withstand high stress. They are not stampings. Design assures maximum bearing efficiency.



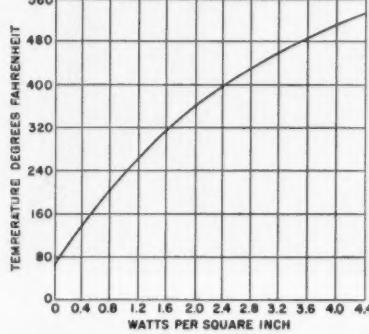
## Process Air Heating Guide

# How to choose the right amount of heat for ovens and process air applications

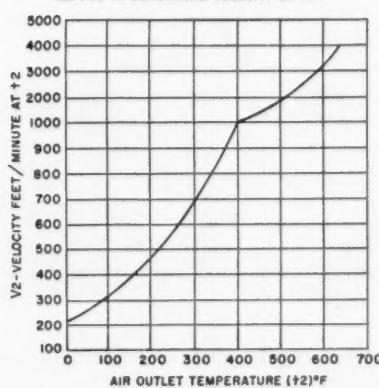
I USE TO DETERMINE LOSSES THROUGH INSULATED WALLS



II USE TO DETERMINE LOSSES FROM ENDS



III USE TO DETERMINE VELOCITY OF AIR



IV This Table Lists Specific Heats

Substance	Average Specific Heat	Weight in Lb per Cu Ft
<b>SOLIDS</b>		
Aluminum.....	0.23	160
Antimony.....	.052	423
Asphalt.....	.40	65
Bee's wax.....	.031	610
Bismuth.....	.10	525
Brass.....		
Brickwork and Masonry.....	.220	140
Carbon.....	.204	...
Copper.....	.10	550
Glass.....	.20	165
Graphite.....	.20	130
Iron, cast.....	.13	450
Iron, wrought.....	.12	480
Lead, solid.....	.031	710
Lead, melted.....	.04	
Nickel.....	.11	550
Paper.....	.45	58
Paraffin.....	.70	56
Pitch, hard.....	.40	83
Rubber.....	.057	95 ±
Silver.....		655
Solder (50% lead—50% tin).....	.04	580
Steel.....	.12	490
Sugar.....	.30	105
Sulphur.....	.203	125
Tin, solid.....	.056	60
Tin, melted.....	.064	455
Type metal (85% lead—15% antimony).....	.040	670
Wood.....	.45 ±	134 pine 50 oak
Zinc.....	.095	445
<b>LIQUIDS</b>		
Acetic acid.....	0.472	66
Alcohol.....	.45	55
Benzene.....	.45	56
Ether.....		
Glue (mixed 2 parts water, 1 part dry glue).....	.503	46
Glycerine.....	.895	69
Mercury.....	.58	79
Oil, cottonseed.....	.0333	845
Oil, cottonseed.....	.47	60
Oil, machine.....	.40	58
Oil, olive.....	.471	58
Paraffin, melted.....	.71	56
Petroleum.....	.51	56
Sulphur, melted.....	.234	...
Turpentine.....	.41	54
Water.....	1.0	62.5

	At Constant Pressure	At 70 F Atmospheric Pressure
<b>GASES</b>		
Acetylene.....	0.35	0.073
Air.....	.237	.080
Alcohol.....	.453	
Ammonia.....	.520	.048
Carbon dioxide.....	.203	.123
Carbon monoxide.....	.243	.078
Chlorine.....	.125	.20
Hydrochloric acid.....	.195	.102
Hydrogen.....	3.41	.0056
Methane.....	.60	.0447
Nitrogen.....	.245	.078
Oxygen.....	.218	.09
Sulphur dioxide.....	.155	.179

Here is condensed information to help you get the most economical electric heaters for your oven and process air design problems.

Generally, strip heaters (a) or tubular heaters (b) are used for natural convection applications. For forced convection heating, fin-tubular heaters (c) are most desirable.



Here's how you figure the amount of heat required:

- Using the formula, lbs of material × specific ht × temp rise (F) over 3412 = kwh required, figure heat requirements for the conveyor.
- Using the above formula, figure heat requirements for the material to be heat treated.
- Figure total area, in square feet, of top, bottom and both sides of the oven. Check Table I to find total kwh losses. Adjust for insulation.
- Figure area of both end openings in square inches. Multiply times factor found in Table II.
- Figure in square feet, the area of the duct. Check Table I for losses. Adjust for insulation.
- Figure cubic feet of volume of oven and duct. Find weight of air at room temperature from Table IV. Multiply your answer times total cubic feet times number of air changes needed per hour. With this answer, use formula from Step 1 above to find kw needed for air change losses.

Total the answer arrived at in the 6 steps above. Add 3 kw as a safety factor. You now know how much heat is required. For more complete information, send coupon below or call your nearest General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y.

Section E723-28, General Electric Co.  
Schenectady 5, New York  
Please send GEA-5096, "Heating Process Air" and GEC-1005, "Catalog of G-E Heaters and Devices."

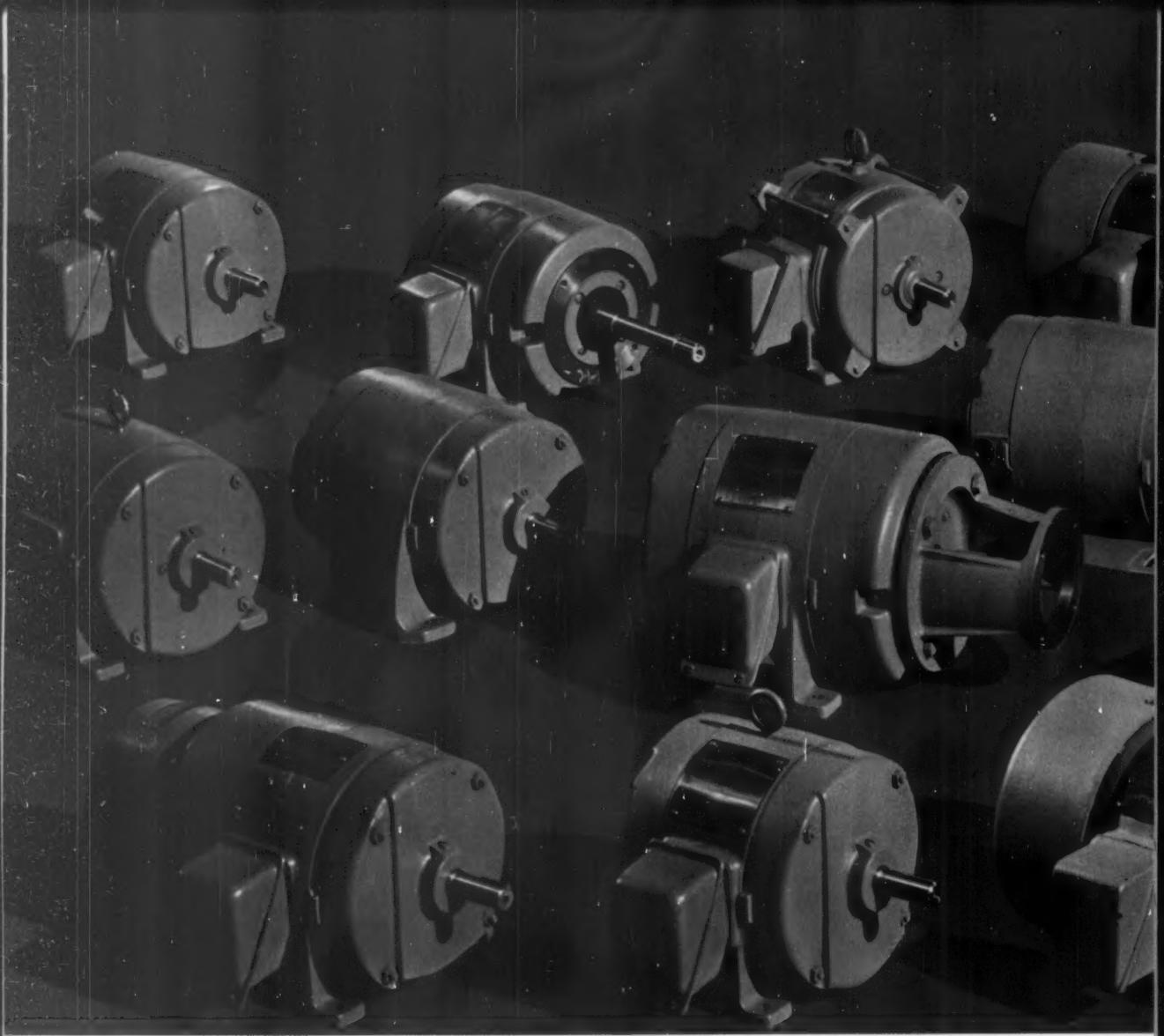
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COMPANY.....

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**GENERAL ELECTRIC**



How General Electric's **TRI 55 CLAD** motor gives you MORE THAN A MOTOR...  
**IT'S 10 TO 1 THE MOTOR YOU  
NEED IS IN THIS PICTURE**

Good odds, aren't they?

And true. The Tri/Clad '55' motor constructions shown above will meet an estimated 91 percent of all applications for small integral-hp motors. Add to this literally thousands of electrical variations possible and you can see: *There's an exact Tri/Clad '55' motor for your application.*

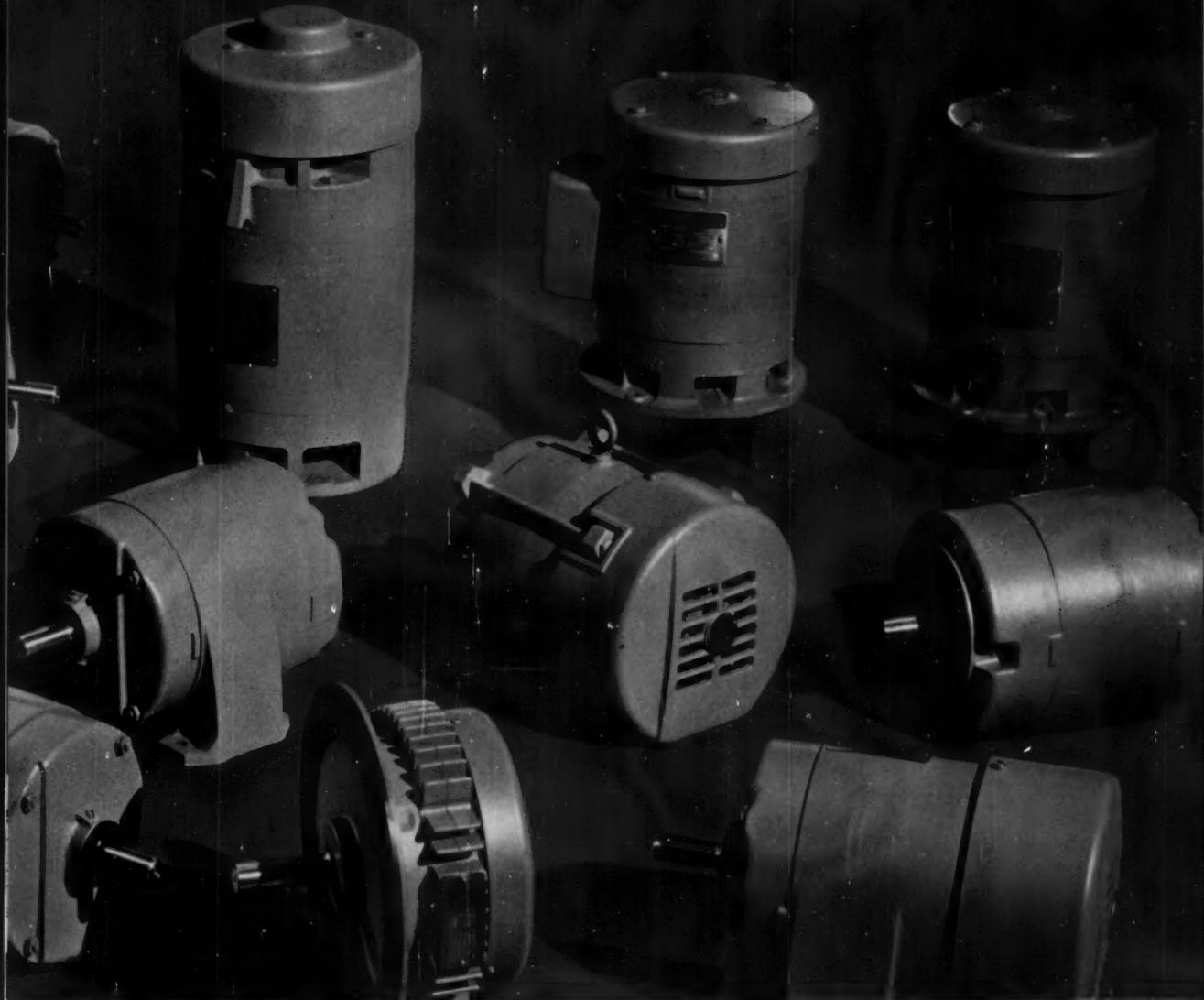
You may choose the rugged, versatile Tri/Clad '55' standard motor. Or, if yours is a special application, there's a complete line of industry-specified motors to choose from. Also, G-E engineers will help you tailor a Tri/Clad '55' motor to meet unusual requirements.

Why not investigate the full line of General Electric Tri/Clad '55' motors today? You'll find Tri/Clad '55'

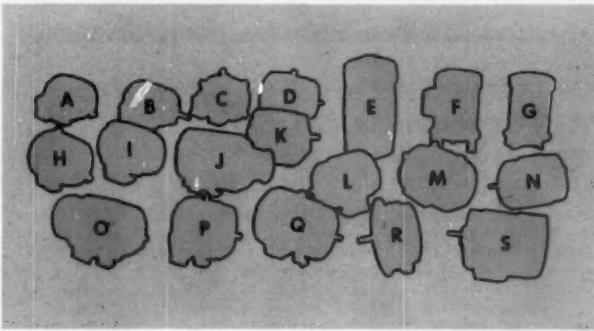
motors give you *more* than a motor . . . in outstanding performance characteristics and many unpaid-for "extras." Contact your nearby G-E Apparatus Sales Office or write Section 840-29, General Electric Co., Schenectady 5, N. Y.

**Other "More Than A Motor" Benefits of G-E Tri/Clad '55' Motors:** On-time Delivery • Expert Application Aid • Fast, Local Backup Service • Constant Design Innovation • Durable, Long-life Performance.

**GENERAL**  **ELECTRIC**



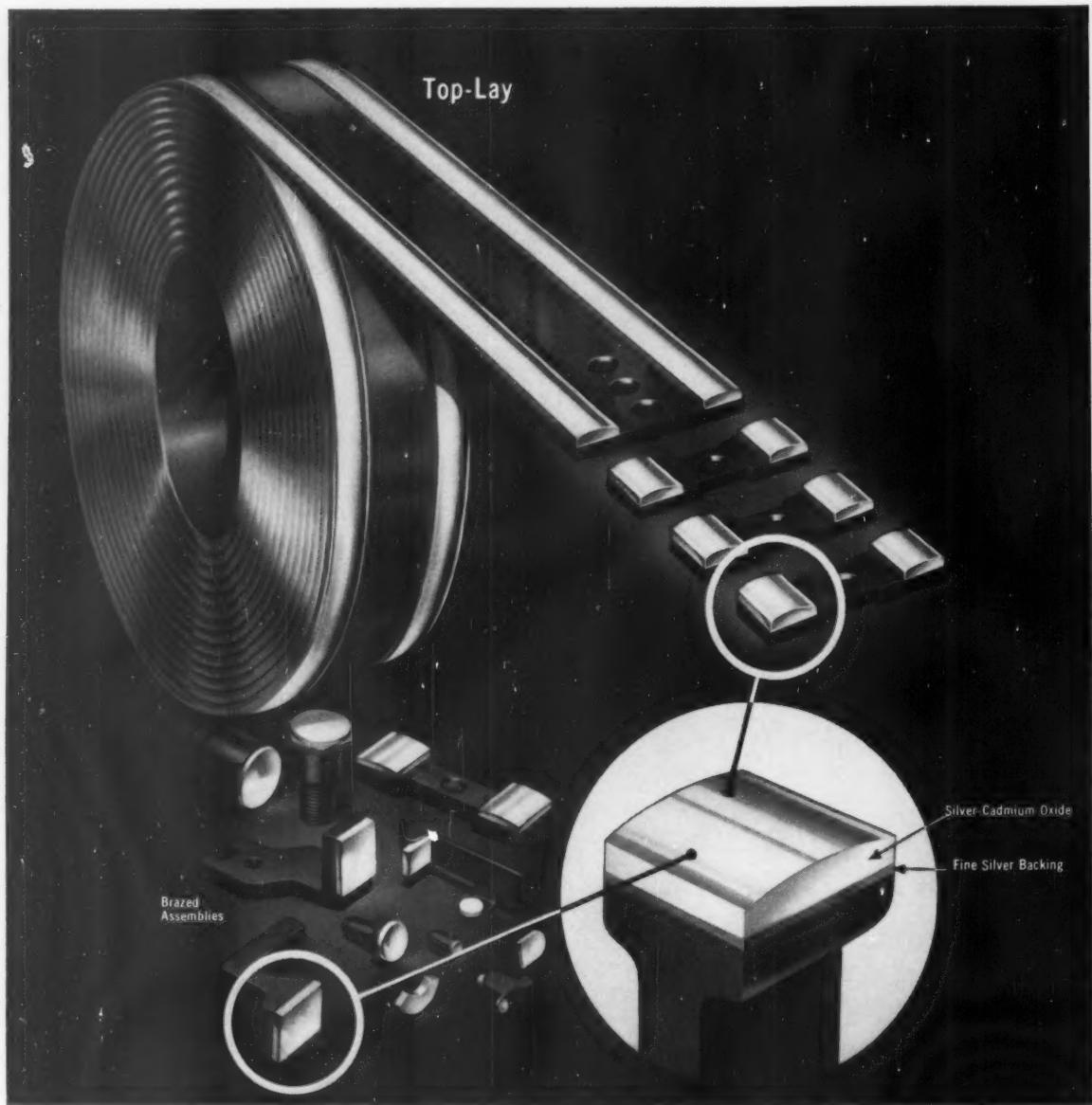
A FULL LINE of General Electric Tri/Clad '55' motors means you can get the right motor for every application.



FULL LINE of Tri/Clad motors includes: (A) Footed dripproof, polyphase (B) C-face, close-coupled pump (C) Explosion-proof, non-vent (D) TEFC (E) Vertical, hollow-shaft (F) Vertical, solid-shaft, P-base, single-phase (G) Vertical, solid shaft, P-base, polyphase (H) Enclosed, air-over (I) Single-phase, general-purpose (J) Hydraulic pump (K) Drip proof, resilient base (L) Single-phase, farm motor (M) Explosion-proof, fan-cooled (N) C-face, round-frame (O) Brake motor (P) Enclosed nonventilated, polyphase (Q) TEFC, severe-duty (R) Thinline, enclosed (S) Fan-cooled, single-phase. All give Tri/Clad '55' motor quality.



A GENERAL ELECTRIC APPLICATION ENGINEER, working with your engineers, can provide valuable assistance in helping you solve unusual motor application problems. He can bring years of integral-horsepower motor experience and knowledge into action for you.



*General Plate Silver-Cadmium Oxide Top-Lay and Brazed Assemblies*  
**Increase Product Performance  
at Substantial Cost Savings**

General Plate Silver-Cadmium Oxide Contacts provide users with many worthwhile advantages. Resistance to welding and arc-erosion, the benefits normally gained with Silver-Cadmium Oxide, are coupled with an ease of fabrication not normally associated with this material. The difference is a heavy fine silver backing that assures a superior bond to the supporting member.

General Plate can supply Silver-Cadmium Oxide in Top-Lay material from which complete contact assemblies

are produced by simple "blank and form" operations. This reduces manufacturing costs substantially, yet assures a better engineered product.

For contact assemblies not readily produced from Top-Lay, Metals and Controls specializes in supplying complete fabricated brazed contact assemblies ready for installation. This can save you

money, time, and trouble.

Silver-Cadmium Oxide Contacts are also available as rivets, buttons for welding, and welding tape.

It will pay you to investigate General Plate Silver-Cadmium Oxide Contacts. Our competent Field Engineers will gladly call at your request and review your contact problems. Write today.



**TEXAS INSTRUMENTS**  
 INCORPORATED

METALS & CONTROLS DIVISION  
 803 FOREST STREET • ATTLEBORO, MASS.

GENERAL PLATE PRODUCTS

General Plate Products: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal • Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

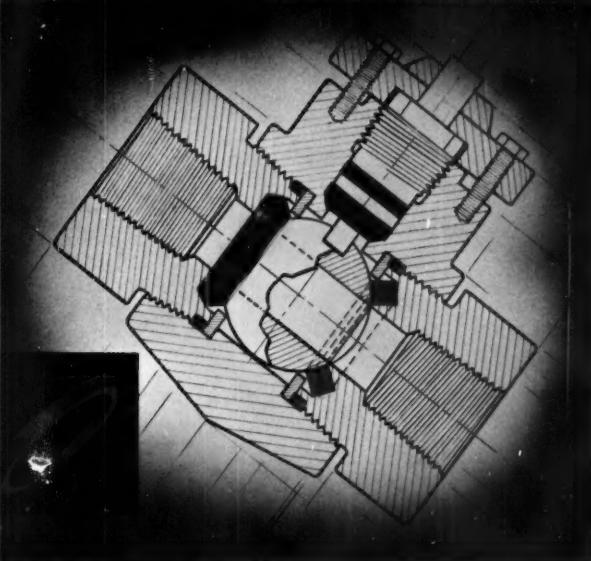


ENGINEERING FACTS ABOUT

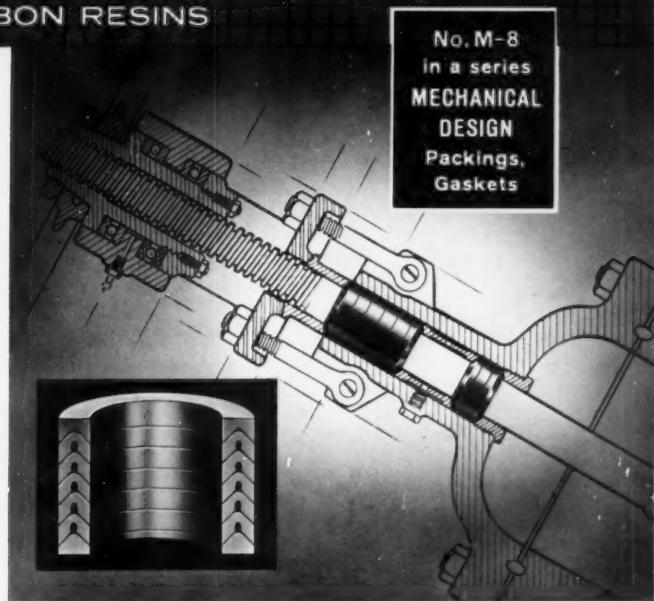
R

# TEFLON<sup>®</sup>

FLUOROCARBON RESINS



**Seats and stem gaskets** of TFE resins assure tight-sealing, no-stick operation in these non-lubricated ball valves used in high pressure butane-propane service. User reports that these valves have been in operation for three and one-half years with no leakage or valve failure.



No. M-8  
in a series  
**MECHANICAL DESIGN**  
Packings,  
Gaskets

**V-ring packings** of TFE resins in valves for paper mill service eliminate the frequent changes of packing and periodic adjustments formerly required. In addition, losses of corrosive liquor are eliminated and wear on valve stems is sharply reduced.

## Maintenance and replacement costs go down...productive capacity goes up...with packings and gaskets of TEFLON<sup>®</sup>

The two examples above typify the cost-cutting advantages of Du Pont TEFLON TFE resins as packing and gasket materials. In all applications, the use of TFE resins provides long service life . . . with the resultant savings in maintenance and replacement costs, plus increased productive capacity due to less downtime. In addition, a TFE resin can be used as an all-purpose packing and gasket material because it is resistant to virtually all chemicals and solvents over a temperature range from -450°F. to 500°F. This simplifies standardization. TFE resins are not affected by materials being processed and vice versa. The low friction characteristics of TFE resins often permit their use without lubrication, minimize torque requirements and reduce wear on pistons and shafts.

These are generalizations that have been put to the hard test of dollars-and-cents cost accounting in many

hundreds of specific applications. In many instances, TFE resins have been found to be the only material that would give satisfactory performance. Also, when service demands are not exceptionally rugged, the increased reliability and longer life made possible by TFE resins have led to their specification in an increasing number of packing and gasket applications.

It will pay you to evaluate the use of TFE resins in your designs and equipment. To determine which of the many products made from TFE resins may be best suited for your packing or gasket application, consult the handy table on the next page.

OVER

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

# Guide to products made from TFE resins used in packing and gasket applications

APPLICATION	SOLID GASKETS	FILLED COMPOSITIONS	ENVELOPES	IMPREGNATED ASBESTOS CLOTH	SPRAL WOUND	IMPREGNATED TFE RESIN FELTS	IMPREGNATED FIBER FELTS AND CLOTHS	V-RINGS	CUP AND CONE	IMPREGNATED ASBESTOS BRAIDED PACKINGS	SHREDDED PACKING	BRAIDED FILAMENT	UNMODIFIED RESIN	LAMINATED WITH GLASS CLOTH
METALLIC FLANGES	A	B	D	A	A	A	C							
NONMETALLIC FLANGES			D	A		A	C							
GLASS LINED FLANGES			D	A		A	C							
GLASS FLANGES			D	A		A	C							
RECIPROCATING RODS								E		G	F	K		
ROTARY SHAFTS										H	J	K		
VALVE STEMS								E	E	G	F	K		
PACKED EXPANSION JOINTS								E	E	G	F	K		
PISTON RINGS	A												A	
MECHANICAL SEAL PACKING								E	E					
VALVE SEATS OR DISCS	B												C	B
DIAPHRAGMS	B												C	B
MECHANICAL SEAL FACES	A													
O-RINGS													A	

A—Usable to 550°F.

B—Generally used in the 400° to 500°F range.

C—Generally usable up to 400°F.

D—Usable to 550°F depending on the type of filler.

E—Can be obtained as unmodified resin or filled composition.

F—Preferably used with spacer rings.

G—The braid over braid type is preferred.

H—Generally usable with surface speeds up to 1200 F.P.M. The square plaited braid is preferred.

J—Generally usable for surface speeds in excess of 1200 F.P.M. Should be used with spacer rings.

K—Adapted for severe corrosive service.

**Maximum performance and economy** is obtained when gaskets and packings are properly designed and chosen for the specific sealing operation you have in mind. Optimum operating limits and conditions for a variety of types and uses are indicated in the table above.

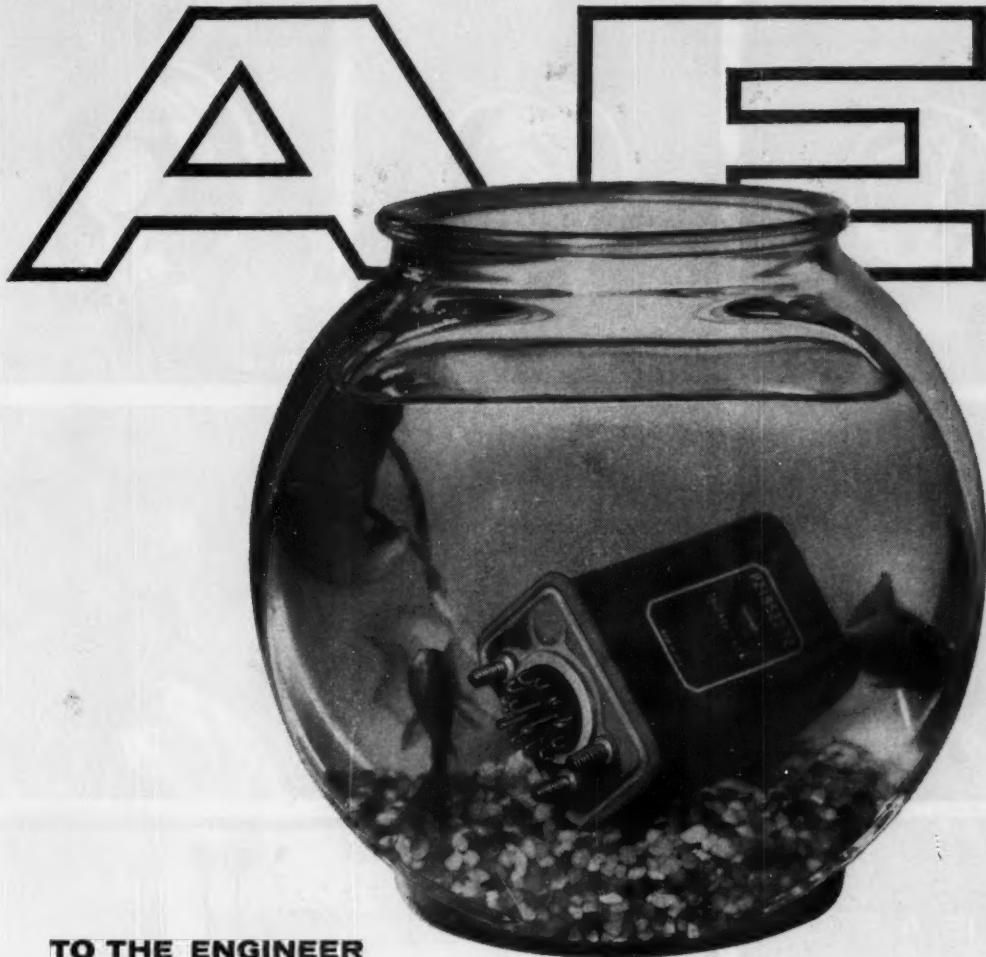
**FOR MORE INFORMATION** about the wide variety of forms in which TFE resins are available for sealing applications, consult your supplier. And for additional information about properties and characteristics of TFE resins, and the many ways they have led to improved, economical designs, write to: E. I. du Pont de Nemours & Co. (Inc.), Polymers Dept., Room T-25317, Nemours Building, Wilmington 98, Delaware.

**In Canada:** DuPont of Canada Limited, P.O. Box 660, Montreal, Quebec.



**TEFLON**<sup>®</sup>  
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



**TO THE ENGINEER**

## looking for an airtight case

Need relays or stepping switches that will stay fresh as daisies—even in environments of high humidity, gritty dust, or extremes of temperature or pressure? You can get them, securely housed in ideal atmospheres of their own.

**AE makes an airtight case out of every job by completely evacuating the prewired assembly, replacing the air with a dry, inert gas to a pressure of at least one atmosphere, and tightly sealing the housing. Then we test it, and if there's a single, tiny leak—enough to pass 1 cc of air in 30 years—we reject the assembly! Here's real protection from adverse environmental conditions (from tampering, too).**

Ask for AE's Catalog 4083 on Hermetically Sealed Enclosures. It shows the wide variety of housing sizes and shapes available—with hook terminals, socket or cable plug-ins, or special printed-circuit connectors. Into these housings AE will put relays and switches assembled and wired to your specifications—or we will design and deliver complete control packages or systems. Chances are we can do the job at less cost, too.

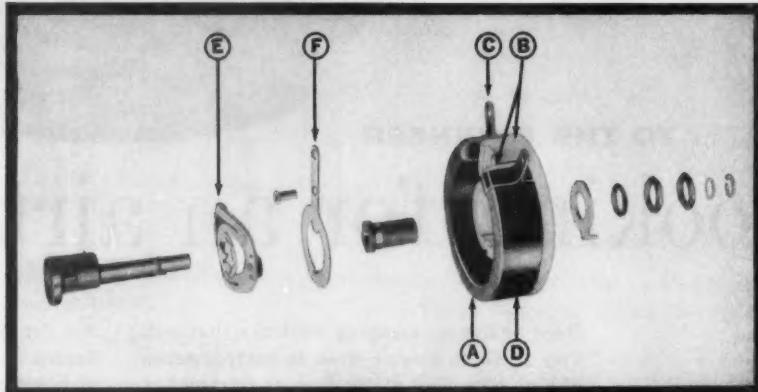
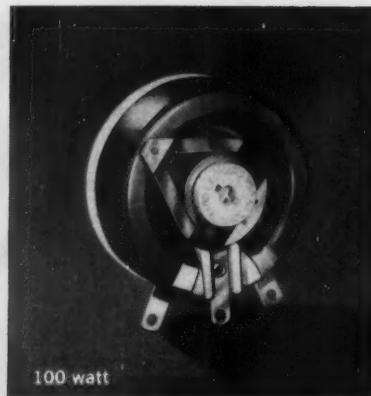
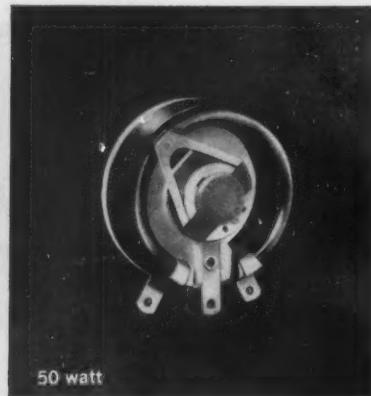
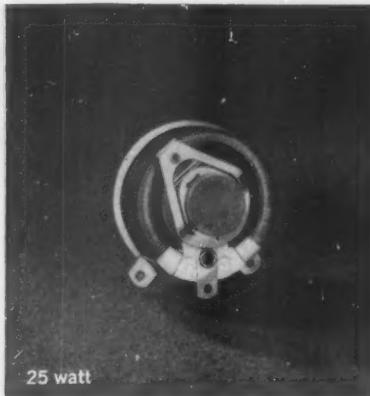
If you have a sticky control problem, just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., 185 Bartley Drive, Toronto 16, Ontario.

**AE  
CAN  
DO**



**AUTOMATIC ELECTRIC**  
Subsidiary of  
**GENERAL TELEPHONE & ELECTRONICS**





### From 25 to 300 watts these VITROHM ring rheostats are engineered for longest life, maximum reliability

To be sure about smooth, trouble-free control in the 25- to 300-watt range—just specify a VITROHM rheostat.

You get smooth control: Close-laid turns (A) of special high-stability, low-temperature-coefficient wire or ribbon to insure smooth gradual resistance change from zero to maximum.

You get reliability: VITROHM ring rheostats are engineered for permanence from highest-grade ceramic base and core (B), durably bonded, tinned-alloy terminals (C), to final craze-proof, shock-resistant, long-lasting VITROHM bonding (D).

You get positive action: Self-lubricating twin-shoe contacts—exclusive with W/L—on balanced beryllium copper contact arm (E) eliminate backlash, contribute to smooth operation, minimize wear on resistance wire (A), assure positive contact to collector ring (F).

You get many more features than we can detail here. Check them all in W/L Bulletin 60RR (and, above 300 watts, check "plate rheostats" in Bulletin 60A). Either bulletin, yours for the asking. Ward Leonard Electric Co., 58 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) **6-6**

**Write for list of stocking distributors**



**WARD  
LEONARD**  
**ELECTRIC COMPANY**  
**MOUNT VERNON, NEW YORK**

**LIVE BETTER...Electrically**

**Reliable—Engineered Controls Since 1892**



# BOLT EFFICIENCY and FLANGE LOADS

Gasket leaks are most often caused by inadequate flange pressure. One reason: bolt friction soaks up torque, produces wide variations in bolt efficiency, makes flange load calculations unreliable.

E. M. SMOLEY,  
Research Physicist  
Armstrong Research and Development Center

Adequate flange pressure is the single most important factor in the success of a gasketed seal. In fact, if sufficient flange pressure is available, many gasket problems arising from other considerations might never become serious.

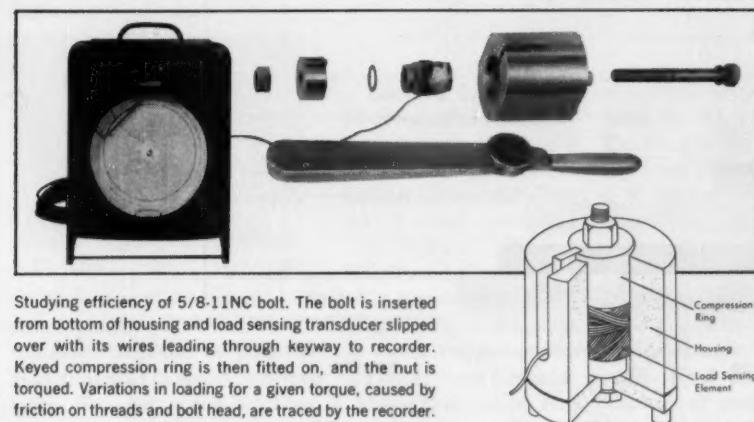
Although it is generally known that friction causes variations in bolt efficiency, little data has been available to indicate the extent of the problem. As a result, arbitrary compensations for friction are usually on the low side.

Lubricated threads give high bolt efficiency and result in gasket loads that approach the values calculated from bolt torque.

Data obtained with this Armstrong bolt efficiency test device has led to a method of relating apparent flange pressures (arrived at by calculation) to actual pressures developed in the flange. This procedure compensates for varying conditions of bolt threads.

This data, combined with other new information on seal points of Armstrong resilient gasket materials, substantially reduces the amount of experimental time that is sometimes required to arrive at adequate flange loading. And it will be helpful to designers in meeting the minimum sealing conditions for a particular flange design and gasket material.

Detailed information on this subject and related problems of gasket selection, design and performance are contained in



Studying efficiency of 5/8-11NC bolt. The bolt is inserted from bottom of housing and load sensing transducer slipped over with its wires leading through keyway to recorder. Keyed compression ring is then fitted on, and the nut is torqued. Variations in loading for a given torque, caused by friction on threads and bolt head, are traced by the recorder.

Calculating flange loads is a relatively simple matter when the number, size and torque of bolts are known. Leaks often occur, however, in gasketed joints where flange loads as calculated are thought to be adequate . . . or more than adequate . . . to form a seal.

Such leaks are sometimes blamed on torque loss, but the real problem usually is that the flange pressure is too low to form a seal. And the reason is that flange loads arrived at mathematically almost never equal the true load on the gasket.

The explanation is friction . . . friction on threads and bolt heads that soaks up torque and reduces substantially the pressure available to squeeze the gasket.

Armstrong research engineers have developed a device (shown above) which measures the effect of bolt efficiencies of varying screw thread conditions.

Dry or rough threads, for example, give low bolt efficiencies which develop actual gasket loads much lower than torque readings would indicate. In some cases, as much as 90% of the torque is lost in thread or bolt head friction.

the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7103 Dean Street, Lancaster, Pennsylvania.



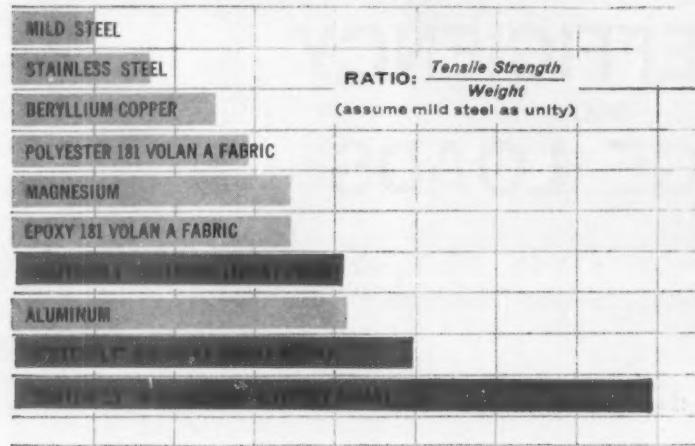
GASKET  
DESIGN  
MANUAL

**Armstrong GASKET MATERIALS**

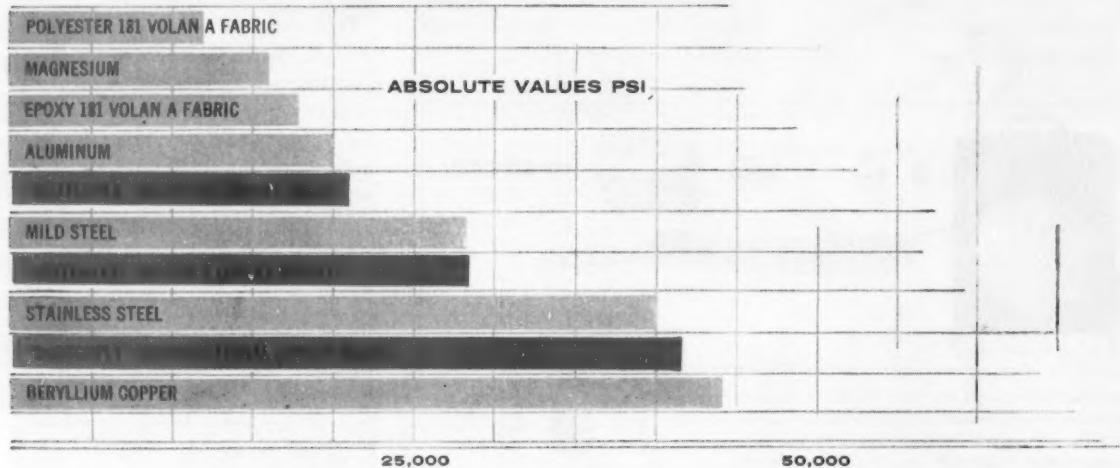
1860-1960 Beginning our second century of progress

S  
C

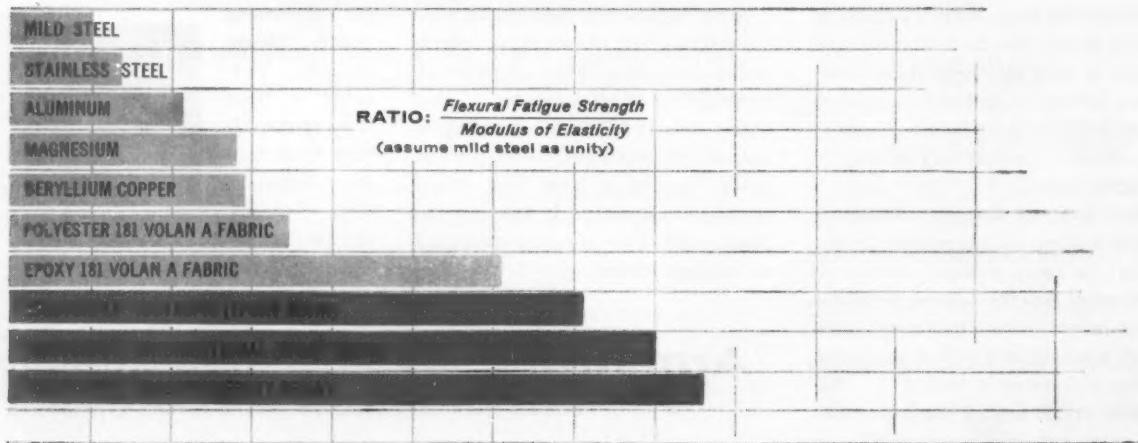
## Tensile strength-weight ratios



## Flexural-fatigue strength @ $2 \times 10^6$ cycles



## Allowable flexural-fatigue deflection @ $2 \times 10^6$ cycles



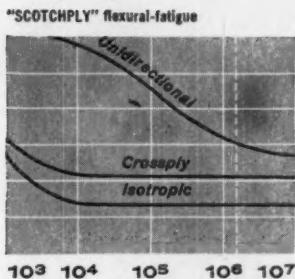
REG. U.S. PAT. OFF.

# SCOTCHPLY

BRAND

## REINFORCED PLASTIC

*A revolutionary structural material  
offers a unique combination of properties*



Looking for a structural material with a superior strength-weight ratio and exceptional fatigue strength? You get it—and more—in "SCOTCHPLY" Brand Reinforced Plastic.

"SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic reinforced with continuous non-woven glass filaments oriented to your specific stress requirements. It is available in epoxy, phenolic and other resin formulations. You get a combination of properties unlike any other structural material on the market.

Compare "SCOTCHPLY" Reinforced Plastic to other

structural materials in the graphs on the opposite page. Look at the tensile strength-weight ratios. Then check the fatigue strengths and allowable flexural-fatigue deflections (taken at an arbitrary  $2 \times 10^6$  cycles from the S-N curves shown reduced at left). Valuable combinations? You bet.

And that's not all. "SCOTCHPLY" Reinforced Plastic has excellent resistance to corrosion and water absorption, low thermal conductivity, low puncture sensitivity, good puncture and dent resistance. It is sold in uncured sheets or rolls containing a controlled ratio of glass to resin. Heat and light pressure in matched metal dies, vacuum or pressure-bag molding cure it into rigid form. It can then be sawed, machined, sanded, milled, turned, drilled or tapped.

**FOR COMPLETE INFORMATION** and technical service, write on your letterhead to Dept. Z. C., Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn. A "SCOTCHPLY" Reinforced Plastic reference manual will be mailed you without charge.



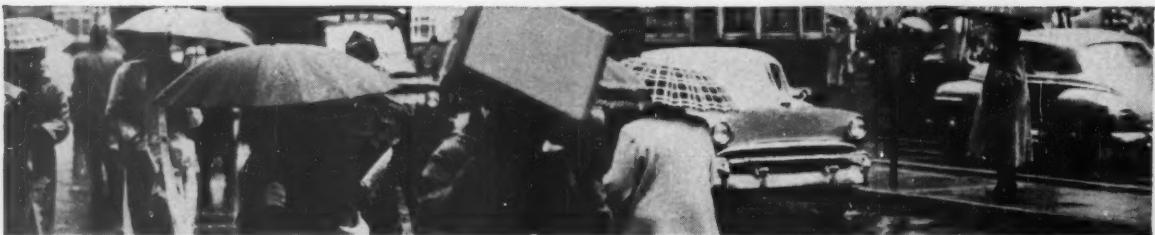
Continuous, non-woven glass filaments are resin-bonded and oriented in...unidirectional...crossply...isotropic form...or combinations to meet your needs.



"SCOTCHPLY" IS A REGISTERED TRADEMARK OF THE 3M CO., ST. PAUL 6, MINN. EXPORT: 95 PARK AVE., NEW YORK 16, N. Y. CANADA: LONDON, ONTARIO

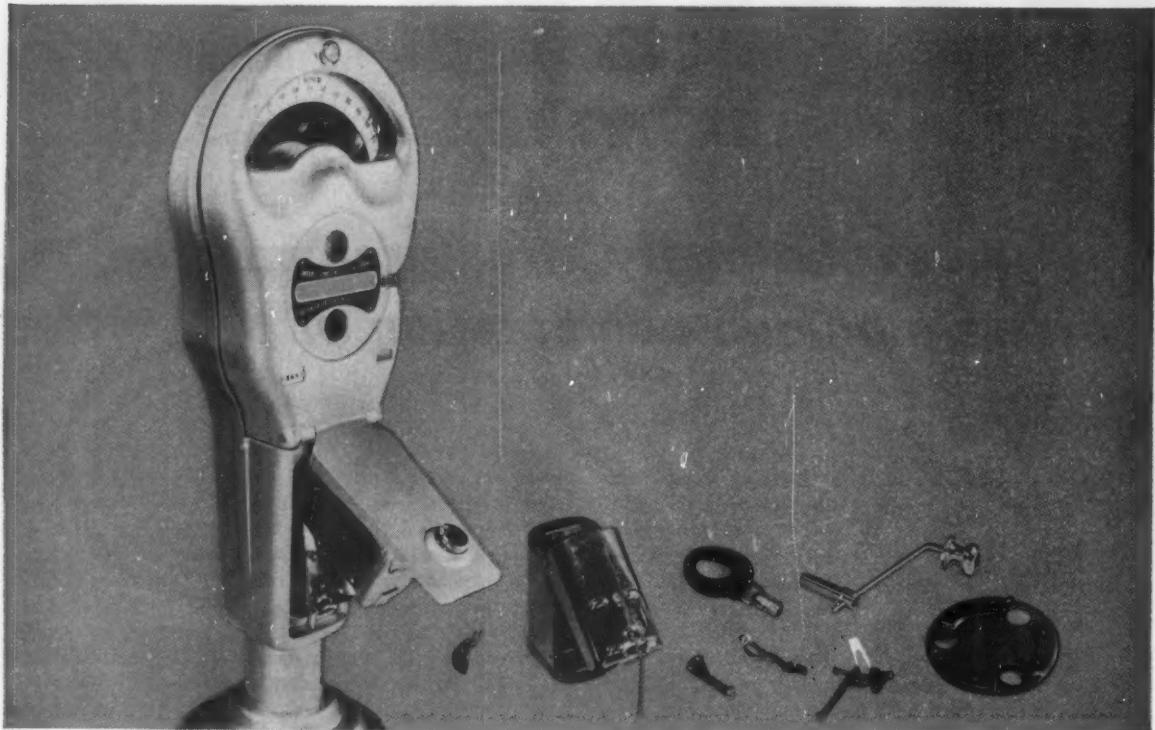
**MINNESOTA MINING AND MANUFACTURING COMPANY**  
... WHERE RESEARCH IS THE KEY TO TOMORROW





for strength, corrosion resistance and long-range dependability

**... it had to be stainless**

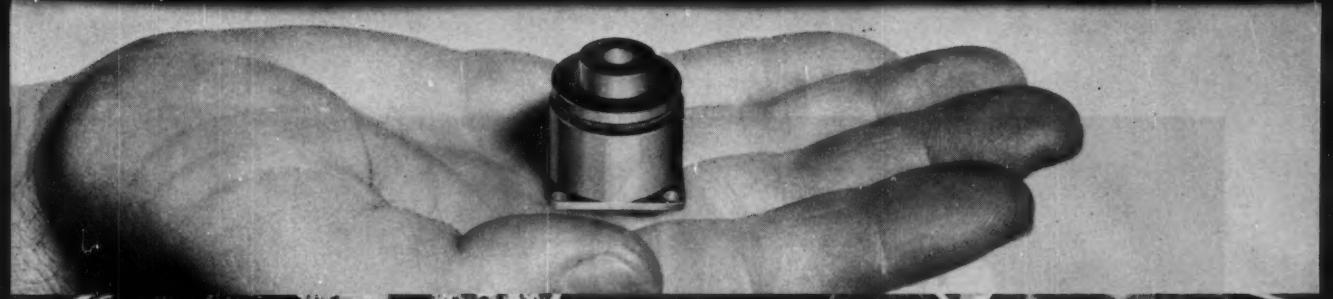


*Of all modern mechanical marvels, only the automobile itself takes more abuse than the parking meter. The meter is not only cussed in conversation, but it is kicked, crashed, bent, rained on, robbed, and stuffed with junk by small boys. Critical parts like timing devices, dumping coin receivers, gear rotating teeth, etc., have been made from Carpenter Stainless for over 15 years by this manufacturer. Carpenter has a Stainless Steel that can give you this same dependability on your important parts. Call in your local Carpenter Representative to look over the requirements for your toughest job. The Carpenter Steel Company, Reading, Pa.*



# Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.  
Alloy Tube Division, Union, N. J.  
Webb Wire Division, New Brunswick, N. J.  
Carpenter Steel of New England, Inc., Bridgeport, Conn.



**WARNER**

new miniature

electric brakes

and clutches

### ...for low-torque instrument drives

Looking for split-second actuation, automatic indexing, smooth inching and jogging, rapid cycling, accurate synchronization, and positive engagement of torque loads up to 1.5 lb in. for compact instrument drives, aircraft components, and similar applications?

These are control advantages now made possible by Warner miniature electric brakes and clutches, which are proved-in-use on products requiring reliable operation under difficult operating conditions.

Electromagnetic principle permits stepless torque modulation, automatic operation, and remote actuation from a variety of electric controls. Compact design gives you high torque per inch (approximately 1 in. dia x  $\frac{1}{8}$  in. length). Two-piece floating armature avoids complex alignments during assembly.

Energized field transmits torque to the armature through the rotor (clutch), or through a replaceable face mounted directly to the field (brake). Field is always stationary. It is not subject to wear, requires no slip rings or brushes. Easily adjusted voltage through two 12-in. lead wires gives you cushioned or abrupt couples or stops.

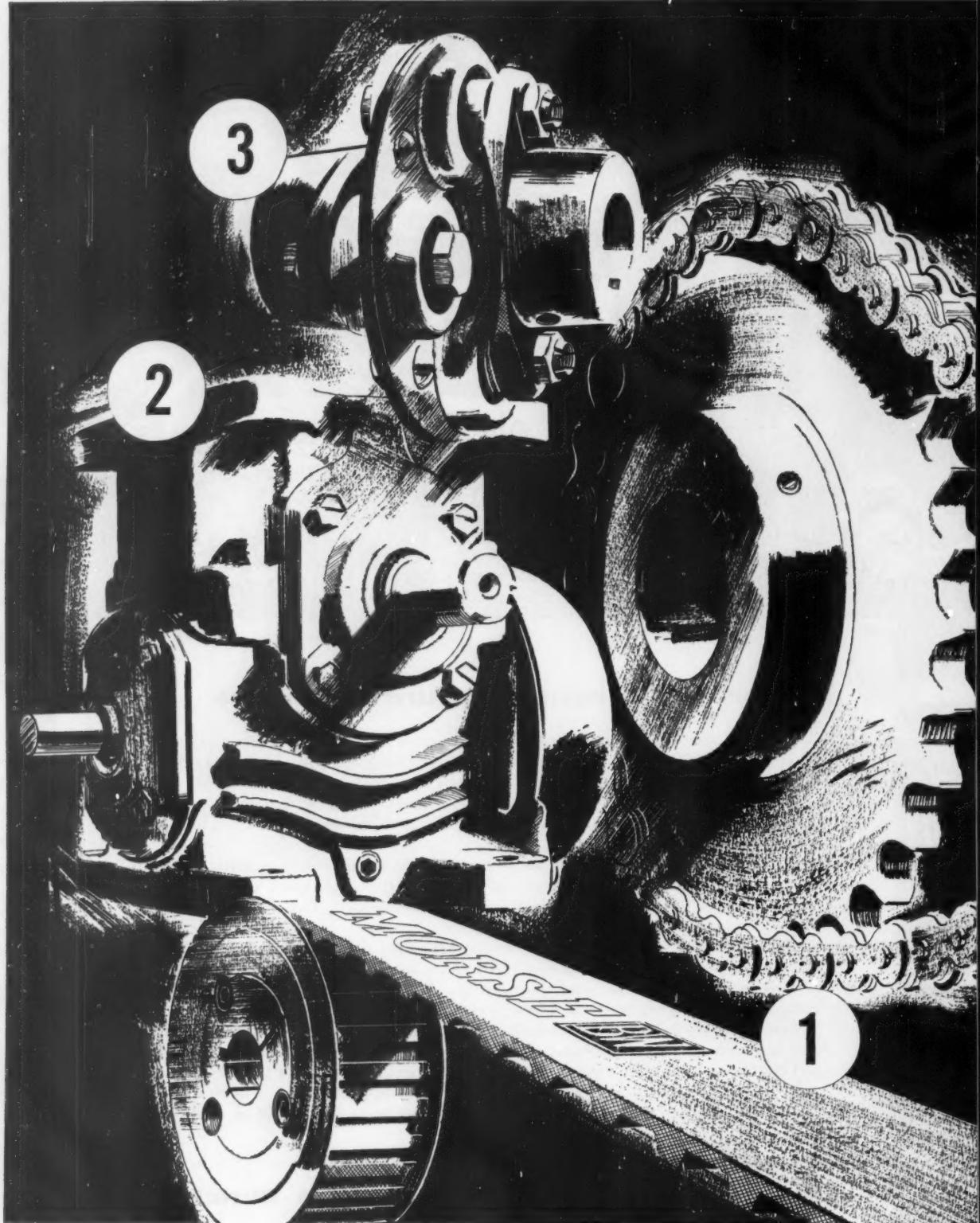
Your Warner representative has a desk-top, plug-in demonstrator. You name the date . . . he'll show you the speed, adjustability, and control-ability of miniature electric brakes and clutches . . . simulate a variety of start, stop, inching, jogging, or torque adjustment applications. Phone him or write us to arrange an appointment. Miniature electric brakes and clutches broaden torque range of Warner units from 1.5 lb in. to 700 lb ft.



originators of electric motion control

**Warner Electric Brake & Clutch Co.**  
Beloit, Wisconsin

Circle 447 on Page 19



**ONLY MORSE  
OFFERS ALL 4**

**1 BASIC DRIVES**

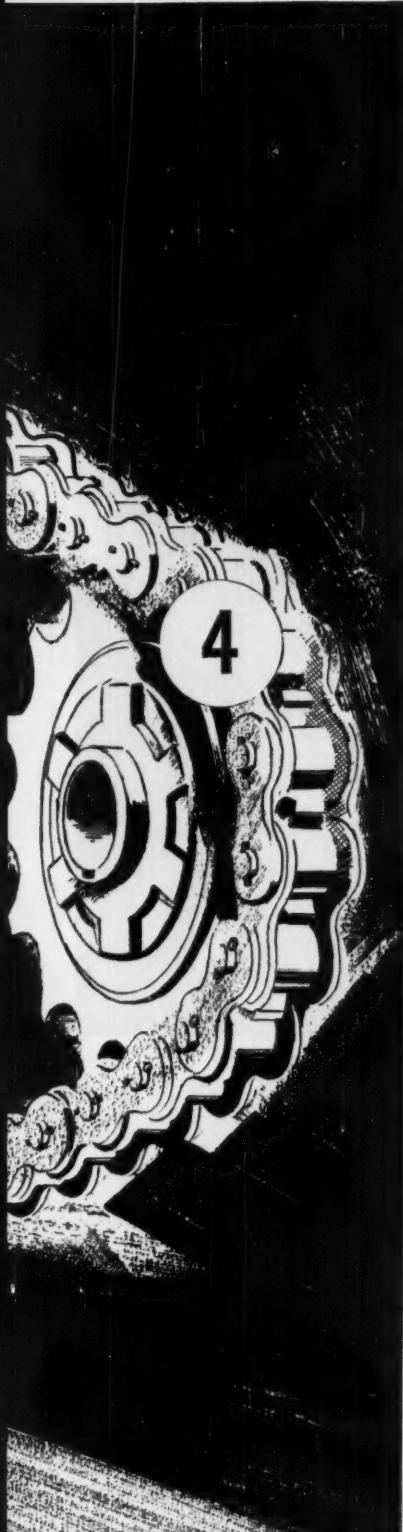
Morse offers a complete line of Roller Chain, Silent Chain, exclusive Hy-Vor® Drives, "Timing" Belts and Sprockets.

**2 SPEED REDUCERS**

Eberhardt-Denver "RW" PowerGear® Reducers, Gearmotors, Worm Gear Reducers, Conveyor Drives, Mitre Boxes, Helical Reducers.

**3 COUPLINGS**

Flexible Roller and Silent Chain Couplings; Morflex Couplings, single and double; Morflex Radial and Marine Couplings.



#### 4 CLUTCHES

Morse Cam (Over-Running, Back Stopping, Indexing), Fullmore, Over-Center, Torque Limiter and Centrifugal Styles afford flexible control of power.

March 17, 1960

Only Morse offers all 4 . . . only Morse can accept

## Full responsibility for your industrial power drive

Drives, speed reducers, couplings and clutches . . .  
designed better, built better, distributed better and backed by the  
only company that takes on the whole job of satisfying you

If you have a production process that requires transmission of mechanical power, it just makes good sense to deal with a company that can take on the *whole job*—furnish *all* the components—guarantee your satisfaction with the *complete* power train.

And *only* Morse can do it!

Drives, speed reducers, couplings and clutches: Morse designs them better to work together . . . builds them better to high quality standards for longer life, in a wide variety of sizes and capacities ideally suited to any job. Moreover, Morse distributes them better for broader, faster customer availability.

Morse—the No. 1 supplier of automotive timing chains—has, through

continuous expansion, evolved a complete line of exclusive power-transmission products. Among them, the well-known Morflex couplings . . . H-E roller chain . . . Hy-Vo® drives . . . Rockford Clutches, Eberhardt-Denver speed reducers and full line of components for the broad industrial fields.

Whether your next project calls for a single coupling or a complete power train, your Morse distributor is the man who can help you most. He's always nearby, listed in the Yellow Pages. Or, if you wish, write direct: Morse Chain Company, Dept. 6-30, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

**MORSE**  
**BW**  
A BORG-WARNER INDUSTRY

Circle 448 on Page 19

★ ★ ★ ★ ★

# A NEW "ROLL" FOR OLD GLORY!

★ ★ ★ ★ ★

## ACIPCO CENTRIFUGALLY SPUN ROLL USED IN PRINTING NEW 50-STAR FLAG

Here is an interesting application for ACIPCO centrifugally spun steel tubing. The above view shows an ACIPCO Type 1025 steel roll — 19" in diameter and 44" in length — being machined prior to copper plating. The roll was subsequently engraved with the 50-star pattern, and then utilized for printing multiple reproductions of our new flag on fabric.

Wherever tubular steel applications exist . . . ACIPCO spun steel tubes serve. Completely equipped to produce a wide variety of centrifugally spun and statically cast products, ACIPCO can serve your requirements more efficiently and economically because all its facilities are "under one roof."

For expert consultation on centrifugally spun tube applications in your field . . . call on ACIPCO.

## VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

### SIZE RANGE

Lengths up to 40 feet have been produced to meet modern machinery requirements. O.D.'s from 2.25" to 50"; wall thicknesses from .25" to 4".

### ANALYSES

All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special non-standard analyses.

### FURNISHED

As cast, rough machined, or finish machined, including honing. Complete welding and machine shop facilities for fabrication.

*Write for free illustrated catalog.*



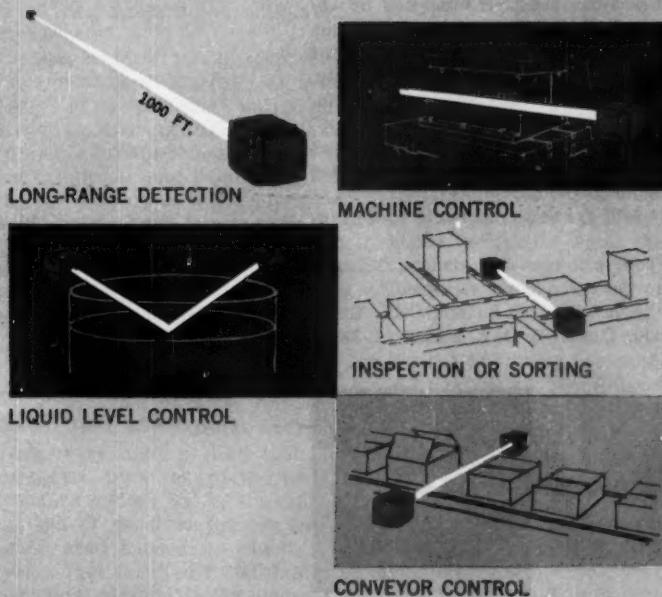
**ACIPCO**  
**SPECIAL PRODUCTS**

DIVISION OF  AMERICAN CAST IRON PIPE CO.  
BIRMINGHAM • ALABAMA

# Announcing **Infrabeam** ...the revolutionary photoelectric control using modulated infrared radiation



Model 9101



**FOR THE FIRST TIME**, photoelectric control is *simple, reliable, and practical* over an extremely wide range of applications.

*Infrabeam* is a totally new type of photoelectric control . . . developed and tested over a period of more than a year, now ready to go to work in your plant or as part of equipment you manufacture. It offers a combination of simplicity, sensitiveness and reliability that has never before been achieved.

New infrared detectors, perfected for missile guidance, are in many ways superior to photocells that respond to visible or ultraviolet light. In *Infrabeam*, the Receiver contains a similar infrared detector which is screened against visible light by a simple optical filter. Further, the infrared beam from the Projector is "modulated" — brightening and dimming at a frequency of 400 cycles per second. The Receiver is electronically tuned to this frequency, so that the control will not respond unless it gets a signal from the associated Projector.

#### WHAT THIS MEANS TO YOU . . .

Compared with standard "general purpose" photoelectric controls, *Infrabeam* provides far greater sensitiveness in countless applications at close or moderate range. At extreme range — as much as 1000 feet — it offers superior reliability and freedom from interference. Because it operates equally well by reflecting the infrared beam from a detected object and into the Receiver, it is the *only* photoelectric control able to reach into "blind" areas with perfect freedom of installation.

Projector and Receiver are attractively housed in anodized cast aluminum. The quick-detach hinge allows easy separation for use as opposed units, or accurate angling for use in reflection. Physical mounting and electrical connections are simplicity itself, and permit quick replacement of either unit without disturbing permanent wiring.

Find out how simple and practical photoelectric control can be for you. **WRITE TODAY FOR COMPLETE DETAILS AND SPECIFICATIONS.**

ELECTRONICS DIVISION  
**CRAMER CONTROLS**  
CORPORATION  
CENTERBROOK, CONNECTICUT



## NEW MINIATURE A.C. MOTOR

*high output for commercial use*

This a.c. synchronous motor costs you only about half as much as its miniature precision counterpart for military applications. In production quantities it is so economical that you can design it into good quality products that now use induction motors. And because you can put this bigger performance motor in smaller spaces, it gives you a head start in miniaturizing your design at the same time you improve product quality.

Vital statistics: This Type CMC motor has a starting torque of .7 oz. in. and a continuous duty torque of .7 oz. in. at synchronous speed. It is 1 $\frac{1}{4}$ " in diameter by 2 $\frac{5}{8}$ " long, and weighs 6 $\frac{1}{2}$  oz. The shaft is precision ground stainless steel, supported by ball bearings. The epoxy-sealed design provides good resistance to normal environmental conditions.

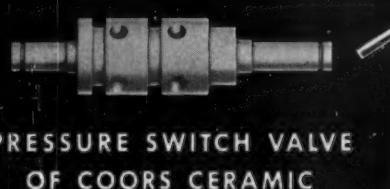
If you have hesitated to design with precision miniature motors in the past, now's your chance!

The Globe motor line includes both a.c. and d.c. models. Globe is pleased to work with you to provide the exact motor you need for your commercial, competitive product. Please write for Bulletin CMC. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

**GLOBE INDUSTRIES, INC.**

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS,  
TIMERS, STEPPERS, BLOWERS & FANS. MOTORIZED DEVICES





PRESSURE SWITCH VALVE  
OF COORS CERAMIC.

## COORS PRECISION CERAMIC PART ENDS CORROSION OF PRESSURE SWITCH

**Ceramic valve for respirator so sensitive  
it can be actuated by infant's breath**

Bird Oxygen Breathing Equipment, Inc., of Palm Springs and San Francisco, manufactures a new, compact, precision respirator used by anesthesiologists in delicate surgical procedures and by physicians to treat lung diseases like asthma and emphysema.

Operation of the instrument is dependent upon the extreme sensitivity of a pressure switch... a switch so sensitive that the slightest intake of breath causes the respirator to operate and begin breathing for the patient... so sensitive that it operates from the breath of a weakened patient, even a new-born infant. The respirator must be able to work perfectly even after years of disuse on the shelf, under conditions of sporadic operation, and under conditions of regular exposure to oxygen, ozone and moisture.

**Metal and alloy parts corrode.** With every metal or alloy that Bird designers tried as parts for the pressure switch valve, the minute amount of moisture present in the gases used caused an electrolytic action that resulted in adhesion of the metal plunger to the sleeve—a slight seizing, but enough to pre-

vent the valve from operating with the necessary sensitivity. Oxidation was also a problem—the slightest roughening of the smooth surfaces prevented valve from functioning.

**Coors Ceramic valve eliminates corrosion.** These problems with metal valves were eliminated when Bird used Coors High Strength Alumina Ceramic (type AD-85) in place of metals. Because Coors ceramics do not corrode or seize, and because properly finished ceramic surfaces have a very low coefficient of friction, the pressure switch works perfectly. Also, because of the extreme hardness of the Coors Ceramic, there is little or no wear—the precise fit of the ceramic plunger and sleeve is retained throughout the operating life of the respirator, tested to 20-million cycles of perfect operation!

During manufacture of the ceramic parts, Coors holds tolerances to 0.000025" on both the O.D. of the shaft and the I.D. of the sleeve. Difference in diameters between shaft and sleeve is held to 0.0001-0.0003".

Coors High Alumina Ceramic is a fine engineering material for ap-

plications requiring a high degree of corrosion resistance or abrasion resistance... also for applications that require high strength under conditions of extreme heat... or for any combination of these conditions.

**Coors Complete Engineering Service.** Coors offers a complete field engineering service to assist you in utilizing these high strength ceramics to the best advantage. Write for complete Technical Data Sheets on Coors Ceramics and facilities. The following Coors Sales Engineers are ready to help you with your current ceramic problems:

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**Coors**  
**COORS PORCELAIN  
COMPANY**

600 Ninth Street, Golden, Colorado

New...

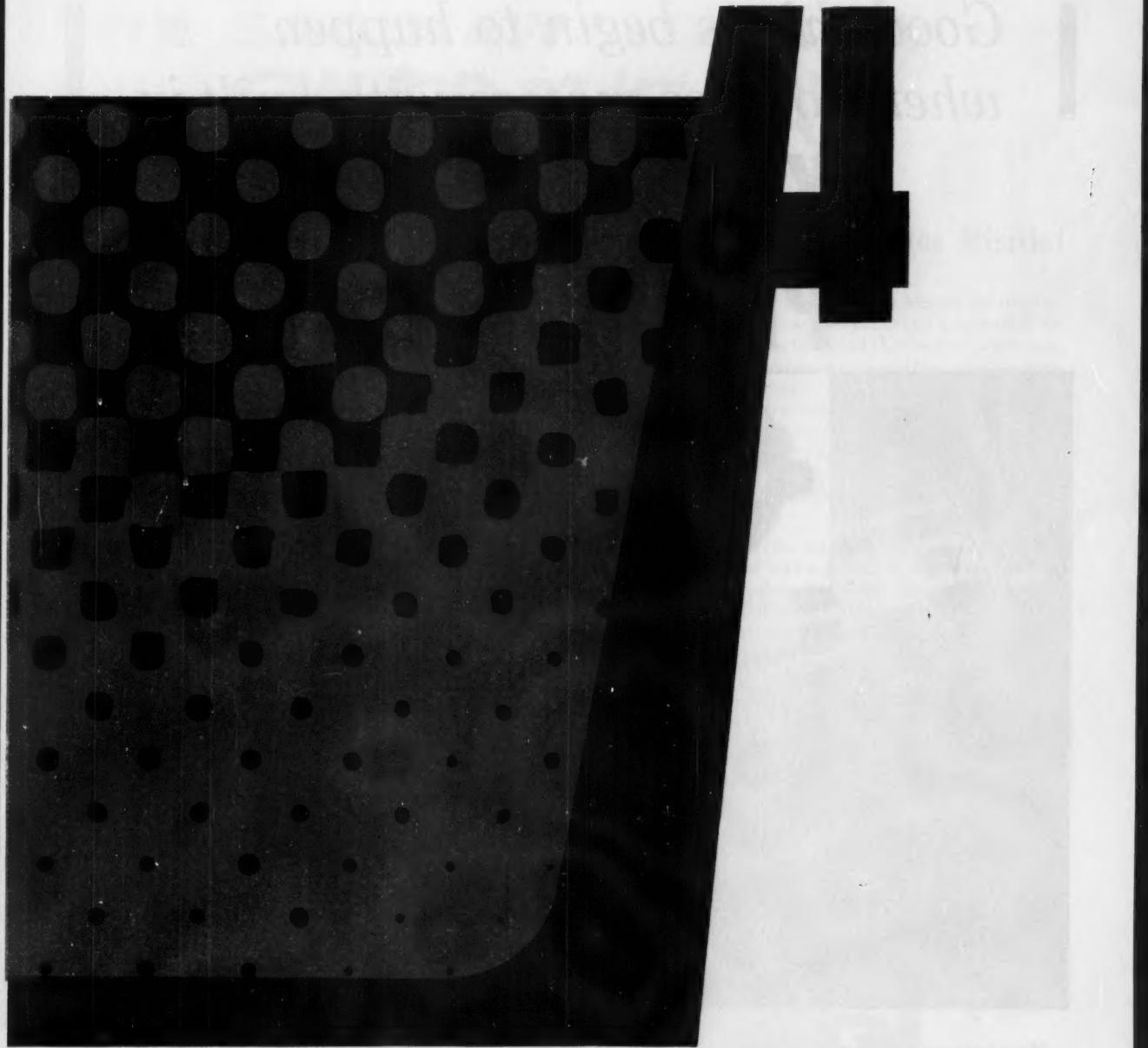
from Great Lakes Steel...

columbium makes the  
difference in fine-grained

GLX-W steel. For the  
products you make,  
investigate the economy of

# GLX-W





### Compare the benefits of GLX-W with other mild carbon steels

GLX-W gives you great yield strength—up to 60,000 psi—thanks to the finer grain structure that comes from columbium treatment. This greater strength permits designers to save up to 35% in weight, compared with ordinary carbon steels.

At the same time, GLX-W gives you the formability and weldability—with no underbead cracking—of regular carbon steels. It is recommended for a wide range of applications. Get complete details from our Product Development Division, Dept. MD-13.



**GREAT LAKES STEEL**

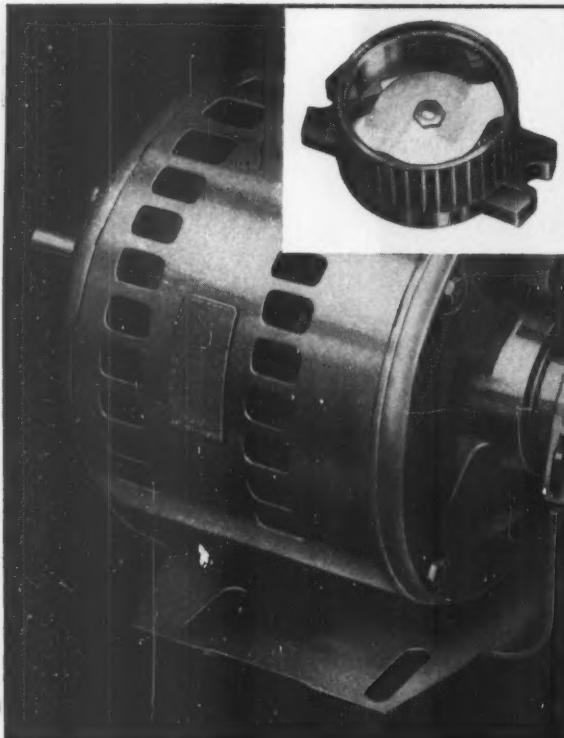
Detroit 29, Michigan

*Great Lakes Steel is a Division of* **NATIONAL STEEL CORPORATION**



*Good things begin to happen  
when you use motors with built-in*

# KLIXON<sup>®</sup> TOTAL PROTECTORS



**You  
Eliminate  
Motor  
Burnouts**

**You reduce  
costly repairs  
and  
replacements**

*You give  
your product  
greater  
reliability*

**You  
Safeguard  
Customer  
Goodwill**

Manufacturers and users of motor-driven equipment can eliminate motor burnouts in their products simply by specifying on their motor purchase order . . . "These motors to have KLIXON Total Protectors."

Built-in as an integral part by the motor manufacturer, KLIXON Protectors permit safe maximum output without failure under abnormal conditions . . . reduce repairs and replacements.

For example, a recent repair shop survey shows that pump motors with built-in KLIXON Protectors reduced motor burnouts by 63.9%.

Protect your motor driven equipment by using motors with built-in KLIXON Protectors. The additional cost is low . . . the savings high. Ask your motor supplier for complete information or write for Bulletin MOPR4.

*Over 200,000,000 motors  
are protected against  
overheating and burning  
out with KLIXON PROTECTORS*



**TEXAS INSTRUMENTS  
INCORPORATED**

METALS & CONTROLS DIVISION  
3203 FOREST STREET • ATTLEBORO, MASS.

**SPENCER PRODUCTS:** Klixon<sup>®</sup> Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

**Klixon Total Protectors available to meet your exacting protection requirements against these conditions:**

1. Running overload with or without high ambient or ventilation blocked.
2. Locked rotor normal voltage such as caused by mechanical failure of driven load.
3. Locked rotor caused by low voltage where decreased torque is insufficient to start load.
4. Locked rotor with main winding only in circuit resulting from open circuit start switch or open circuit in reversing switch.
5. Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
6. Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switchover speed.

# THE SAGINAW<sup>b/b</sup> SCREW SAVED THE DAY WHEN . . .

A Garland Telescopic Crane Had to Lift an Atlas Missile!

"We were *really* up against it when we had to put up a 3-ton Atlas Missile for display at the World Congress of Flight in Las Vegas. Our telescopic crane was unable to "boom up" that much weight, with the high-friction threaded shaft we'd been using.

Thanks to the competent assistance of your factory representative, and prompt delivery of the proper Saginaw Ball Bearing Screw, we licked the problem over a week-end. The Saginaw Screw's 90%-plus efficiency *actually tripled* our crane's boom-raising capability! It even brought us a second order from the Air Force. We're not only going to add Saginaw Screws to every new Garland crane, but install them in every one of the 1200 Garland cranes already in use!" says *Carl Frye, Sales Manager, Garland Crane Co., Long Beach, California.*

Perhaps the Saginaw b/b Screw can give *your* products that greater Sales Appeal you're looking for. Want details? Just write or phone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

The Saginaw b/b Screw converts rotary motion into linear motion with over 90% efficiency. Saves power, space, weight, gives day-in, day-out dependability.

Boom used to raise Able into position for fastening onto Thor missile.



*Actuation To Fit Your Individual Requirements*

Have been built as small as  $\frac{3}{16}$  in. B.C.D. and  $1\frac{1}{2}$  in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

WORLD'S MOST EFFICIENT ACTUATION DEVICE

**Saginaw**  

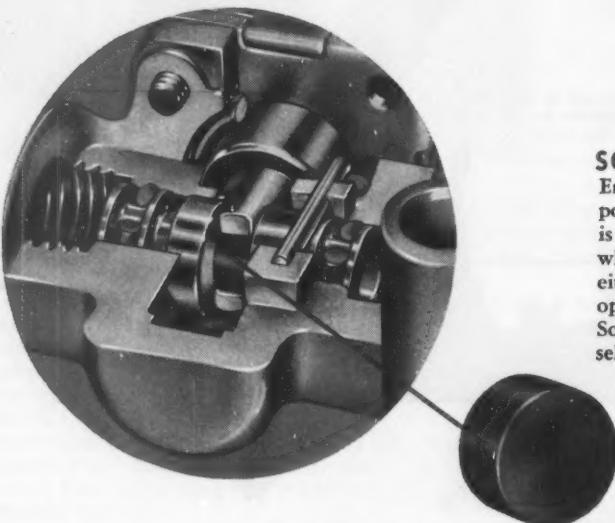
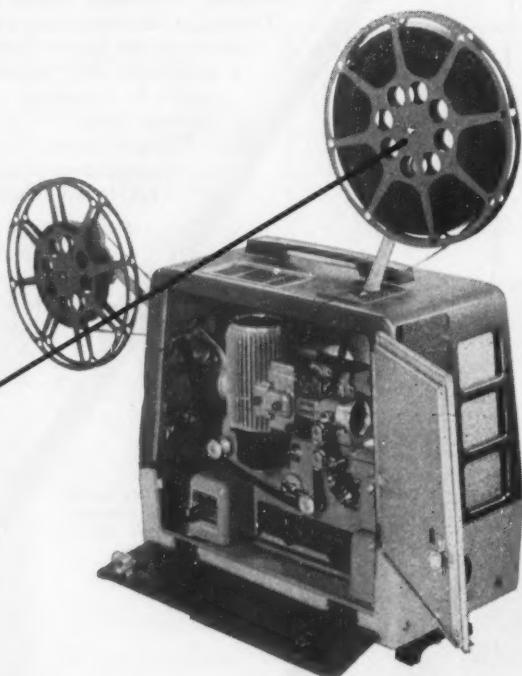

# this is GRAPHITAR.<sup>®</sup>

(CARBON-GRAFITE)

.....

*successful in a wide variety of applications*

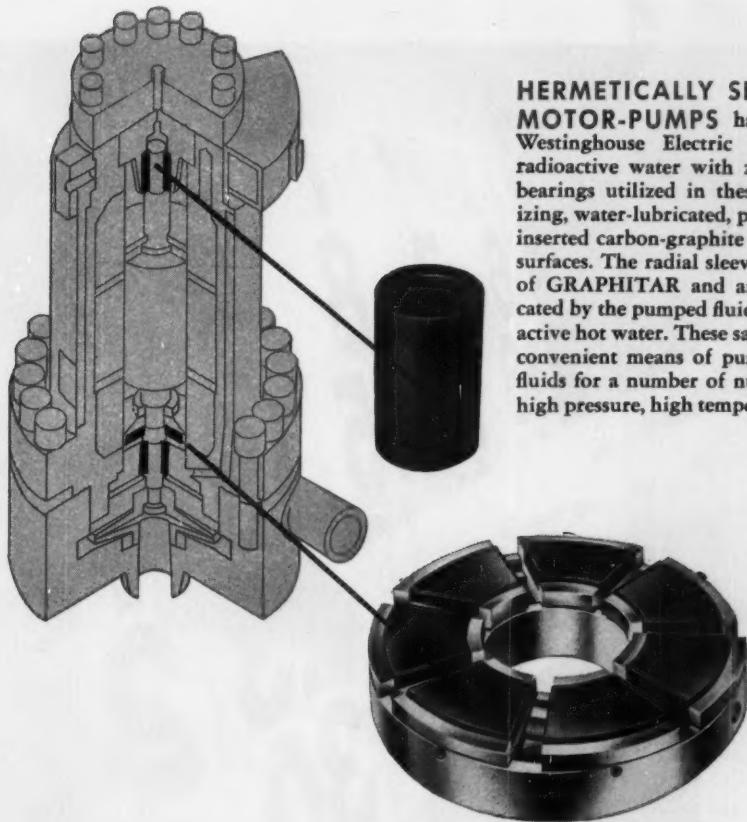
**MOVIE PROJECTOR** built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.



**SOLENOID VALVES** manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

## THE UNITED STATES

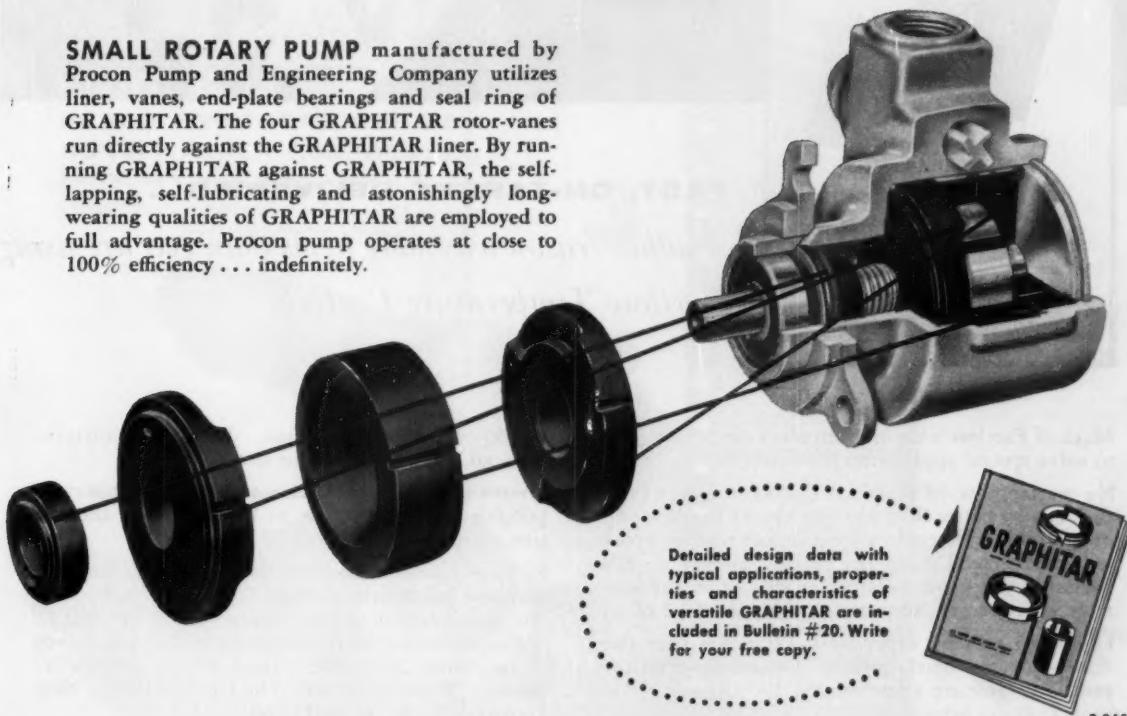
GRAPHITAR<sup>®</sup> CARBON-GRAFITE • GRAMIX<sup>®</sup> POWDER METALLURGY • MEXICAN<sup>®</sup> GRAPHITE PRODUCTS • USG<sup>®</sup> BRUSHES



#### HERMETICALLY SEALED

**MOTOR-PUMPS** have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

**SMALL ROTARY PUMP** manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



# GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN



Send for free brochure, PARTLOW CONTROLS... A handy, condensed catalog of the complete line of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

#### FAST, ON-TARGET DELIVERIES . . .

*Another reason why more firms than ever are using  
Partlow Temperature Controls*

Much of Partlow's business involves special controls to solve special application problems.

No matter how off-standard the control, however, the odds are better than 99-to-1 that the Partlow you order will be delivered well within our regular 3-to-4 week schedule. During the past 12 months — the busiest in our 40-year history — 99% of all the controls we produced went out *on time*, or ahead of it! Of course, prompt, dependable delivery is only one reason for the mushrooming demand for Partlow products. Here are a few others:

**Mercury Actuation**, which lets the Partlow function without an outside power source or temperamental electronic amplification . . .

**Unmatched Design Simplicity**, which enables the Partlow to withstand even extreme conditions of

shock, vibration, corrosion, dust and moisture, without loss of accuracy or sensitivity . . .

**Interchangeability of Elements**, which makes it possible for any Partlow to be serviced at the job site, virtually eliminating "down time."

Partlow makes a complete line of electric, mechanical and pneumatic controls (recording, indicating and non-indicating) for temperatures up to 1100°F. Whatever your application problem, Partlow makes an instrument to handle it efficiently, economically, precisely. Write for details: The Partlow Corp., New Hartford, N. Y., Dept. D-360.



**PARTLOW**  
TEMPERATURE CONTROLS

World Export:  
Ad. Auriema, Inc., 85 Broad Street, New York 4, N.Y.

# COUNTDOWN at **PESCO**

The "Countdown at Pesco" begins in laboratories far from the launching pads. It begins with teams of resourceful Pesco engineers . . . men of vision eminently qualified to meet the technical challenges and rigid reliability requirements of the aerospace industry. All Pesco products shown at right are now critical components of operational air weapon systems. These components are the products of Pesco's advanced engineering that anticipates the sophisticated requirements of the industry . . . plus Pesco's proven capacity for precision production to meet customer delivery schedules. Investigate Pesco's capabilities before you specify on your next project.

## **PESCO PRODUCTS DIVISION**

**BORG-WARNER CORPORATION**

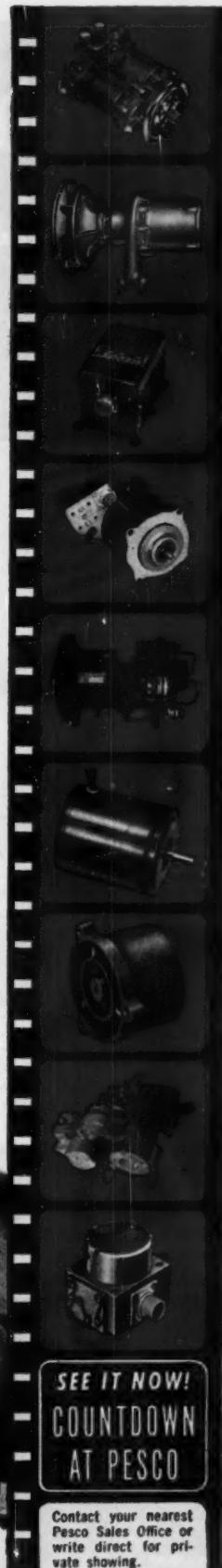
24700 North Miles Road • Bedford, Ohio

EXPORT SALES: Borg-Warner International Corporation  
36 Wabash Avenue, Chicago 3, Illinois



ENR-PC

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**HYDRAULIC PUMPS  
& PUMP/MOTORS**

**CRYOGENIC  
PUMPS**

**STATIC  
INVERTERS**

**ALTERNATORS**

**COOLING  
PACKAGES**

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MOTORS**

**AXIAL FLOW  
FANS**

**HYDRAULIC POWER  
PACKAGES**

**SERVO VALVES**

This new 20-minute full color film enables you to evaluate firsthand Pesco's research, development and production capabilities.

**SEE IT NOW!  
COUNTDOWN  
AT PESCO**

Contact your nearest  
Pesco Sales Office or  
write direct for pri-  
vate showing.

# Got a problem that calls for thread-cutting screws?

PARKER-KALON offers three new, improved thread-cutting screws for every application in every material



## 1 New, Improved P-K Type F\*

... hardened thread-cutting screws developed for use in friable, granular or brittle material. The pilot, with its five tapping flutes, cuts a machine screw thread as the screw is turned in. The Type F is ideal for making fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steels, plastics and resin-impregnated plywood.



## 2 "Pentap"... the new, Improved P-K Type B-F\*

(formerly F-Z) combining the five thread-cutting flutes of the Type F screw with the coarse-pitch, widely-spaced threads of the P-K Type B. The thread-cutting "Pentap" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, and prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.



## 3 P-K® Type L†

... is a completely new and improved thread-cutting screw developed by Parker-Kalon especially for use in Nylon. The Type L functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of the Nylon to allow the full diameter threads to form. Type L offers a particular advantage in Nylon assemblies which must be disassembled for service, because the P-K Type L can be removed and replaced without stripping or galling.

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80 percent! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving, and avoid the possibility of stripping or galling.



FOR SEMS...and Neoprene or Nylon washer STAPS® in thread-cutting and thread-forming tapping screws, or machine screws in any kind of pre-assembled fastener-washer combination, P-K can supply them, too!

KEEP AMERICAN INDUSTRY AT WORK... BUY P-K...MADE IN U.S.A.

\*Patent Pending. U.S. Patent 2,350,346.

FOR SAMPLES OF P-K THREAD-CUTTING SCREWS AND SEMS,  
CALL YOUR LOCAL P-K "BULK-STOCKING" DISTRIBUTOR

**PARKER-KALON**  
fasteners

PARKER-KALON DIVISION, General American Transportation Corporation, Clifton, New Jersey • Offices and Warehouses in Chicago and Los Angeles

we  
control  
even  
this  
kind  
of  
timing!



Timing is a matter of life and death in a hatchery. Every egg must be gently rolled every 60 minutes the way a hen does it: with gentle unfailing precision. And while a hen's instinct tells her just how to evenly expose each part of the egg to exactly the right amount of warmth, in a modern hatchery it's one of our re-cycling timers that does the job. And in a way that reproduces instinct.

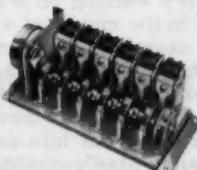
You'll find many other examples of Industrial Timers that solve problems with equal precision in our general catalog. For, in solving numerous timer problems we have developed over 2,000 timer combinations. One of these will most probably be the timer *you* need. And our large stock always assures you of rapid deliveries. See for yourself. Send for our general catalog today.



Timer Delay Timers



Interval Timers



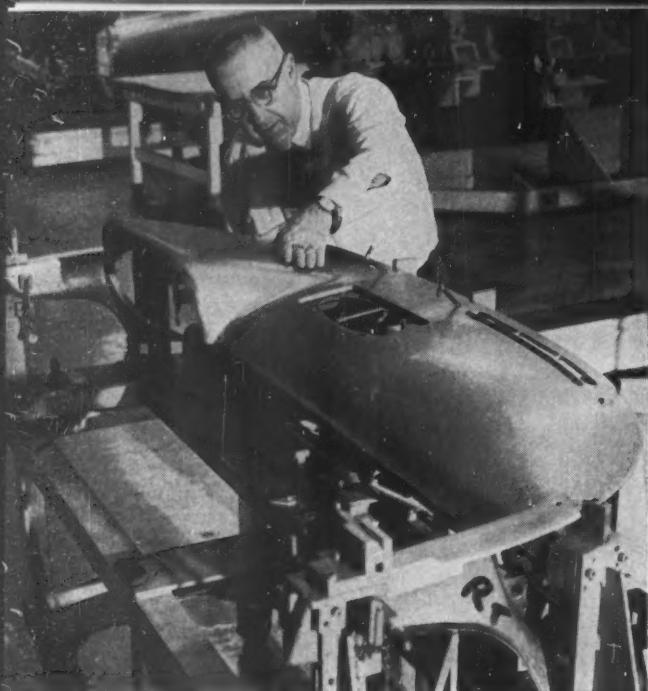
Re-cycling Timers



Running Time Meters



INDUSTRIAL TIMER CORPORATION • TIMERS THAT CONTROL THE PULSE BEAT OF INDUSTRY • 1413 McCARTER HIGHWAY, NEWARK 4, N.J.



**Pattern Sheet**—In the plant of one of the world's largest auto makers, Pittsburgh Steel Co.'s Pattern Sheet was used to make instrument panels. Pattern Sheet is cold rolled sheet steel with a design rolled right into the steel.



**Sheet Steel**—International Harvester specified cold rolled sheet steel from Pittsburgh Steel Co. for many components of the bodies it makes for light trucks. International Harvester demands fine surface, good weldability and formability.

## When Steel From Pittsburgh Means "Pittsburgh Steel"

**Pittsburgh Steel Co. Provides Blue Chip Companies With Wire, Sheet and Tubes For Everything From Missiles to Hairpins**

Performance is the payoff. Go into any manufacturing plant where steel sheet, wire or tubing is pressed, stamped, cut, welded or otherwise formed into finished products. You'll find steel users concerned about how the steel they buy performs on their equipment.

Steel is made to industry-wide standards but there are areas where one producer's steel performs a little better. Perhaps one mill's sheet holds to the exact thickness desired more consistently. Or maybe it consistently does better on tensile strength.

**Pittsburgh Steel has an excellent record in making sheet, strip, wire and tubing which performs better for fabricators.**

Photographs on these pages take you into some fabricating plants and to field applications where specifications for steel are precise because users demand good performance. Pittsburgh Steel makes good by meeting these demands.

Take International Harvester Company. Using cold rolled sheet from Pittsburgh Steel Co., Inter-

national Harvester combines good styling with ruggedness in light truck bodies.

**• Switched to Pittsburgh Steel**—One of the oldest and largest ball bearing makers now uses mechanical tubing from Pittsburgh Steel to make a difficult bearing part. Formerly, alloy bars were used for this high speed machining operation. The company switched to Pittsburgh Steel tubing because it provided more pieces per day, longer tool life, less machining and a lower cost material.

See that oil field "roughneck" up on the monkey board of an oil well rig? He's working on a rig drilling for oil in the middle of a grapefruit grove near McAllen, Tex. On that job Chief Engineer M. D. Frazier of Texkan Oil Co., said: "If you don't have good pipe you have no well. We've never run into defects with Pittsburgh Steel's seamless tubing."

The little springs in the photograph at right have a tough job. Each of these carburetor pump springs will keep a motorist moving

although he may never know of their busy life under the hood of his car. Made of music wire only .014 inch thick these springs are made from wire drawn by Pittsburgh Steel's subsidiary, Johnson Steel & Wire Co. Performance of the steel is tops.

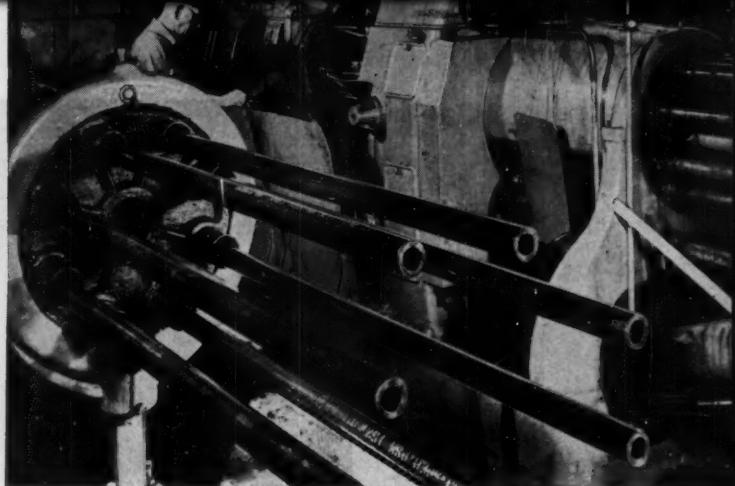
**Or take those seat cushions for a compact car.** Stubnitz Greene Corp. uses Pittsburgh Steel wire to coil this new kind of seat spring, Torflex Spring, because the steel performs well on coiling machines.

A new product, one of many in the making, was developed in 1959. It is Fab-Form, a permanent steel form for concrete floor and roof slabs, which speeds work and lowers costs. Longer and wider than its competitors, it is supplied to users with a new welding technique which speeds installation.

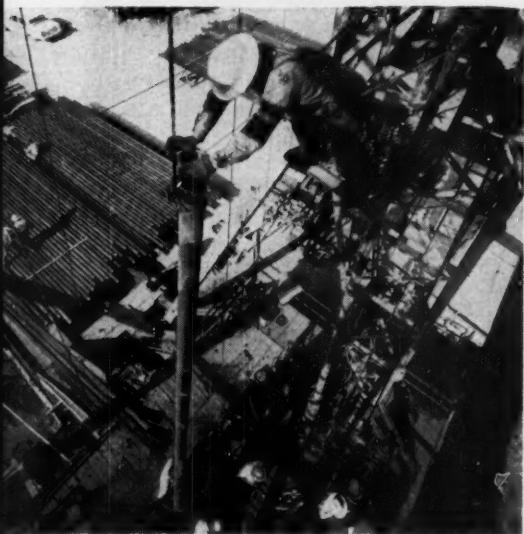
All this is typical of the company's quiet determination to improve facilities, widen markets and diversify products so that customers, employees and stockholders all may benefit.



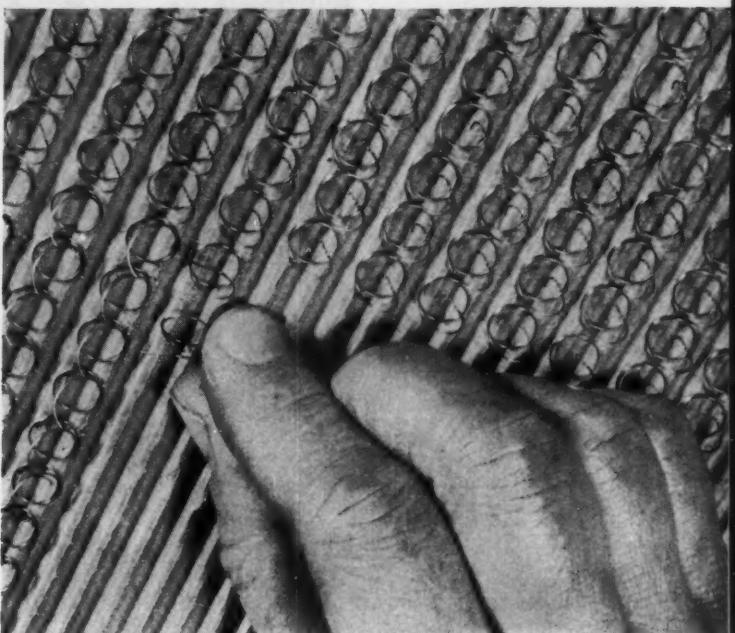
**Manufacturers Wire**—Used here to make a new type spring used in the seat and back cushions of a compact car, Pittsburgh Steel Co.'s manufacturers wire is consistently dependable.



**Seamless Mechanical Tubing**—Not a new weapon but mechanical tubing from Pittsburgh Steel being processed into a bearing part. This manufacturer switched from alloy bars to Pittsburgh tubing and reduced production costs.



**Seamless Oil Country Goods**—That's what they call drill pipe, casing and oil well tubing in the oil fields. Here Pittsburgh Steel casing is being run into a 7,500-foot deep well in Texas.



**Fine Wire Specialties**—Wispy but precise as the pattern they make on the gummed pallet are carburetor pump springs coiled from music wire made by the subsidiary Johnson Steel & Wire Co.



**Construction Products**—A new Pittsburgh Steel product—Fab-Form—goes down on joists preparatory to pouring a concrete slab. Fab-Form is a permanent steel form for concrete roof or floor slabs.

## Pittsburgh Steel Company

Grant Building

• Pittsburgh 30, Pa.



### DISTRICT SALES OFFICES

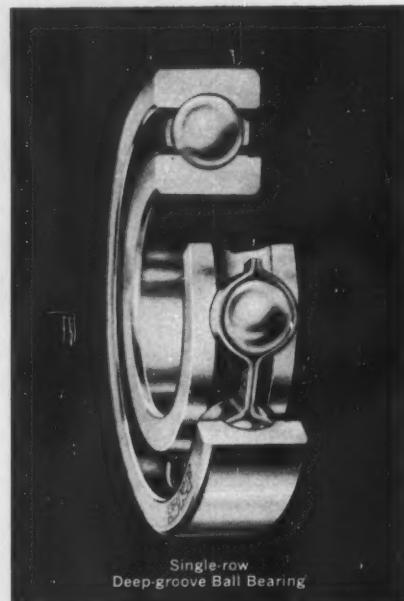
Atlanta  
Chicago

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Dayton

Detroit  
Houston

Los Angeles  
New York  
Philadelphia  
Pittsburgh  
Tulsa  
Warren, Ohio

Circle 460 on Page 19



## Can a standard bearing offer you "more bearing" for your money?



It can if it's made by **SKF**—because all **SKF** bearings, both ball and roller, offer special qualities at "production" bearing prices.

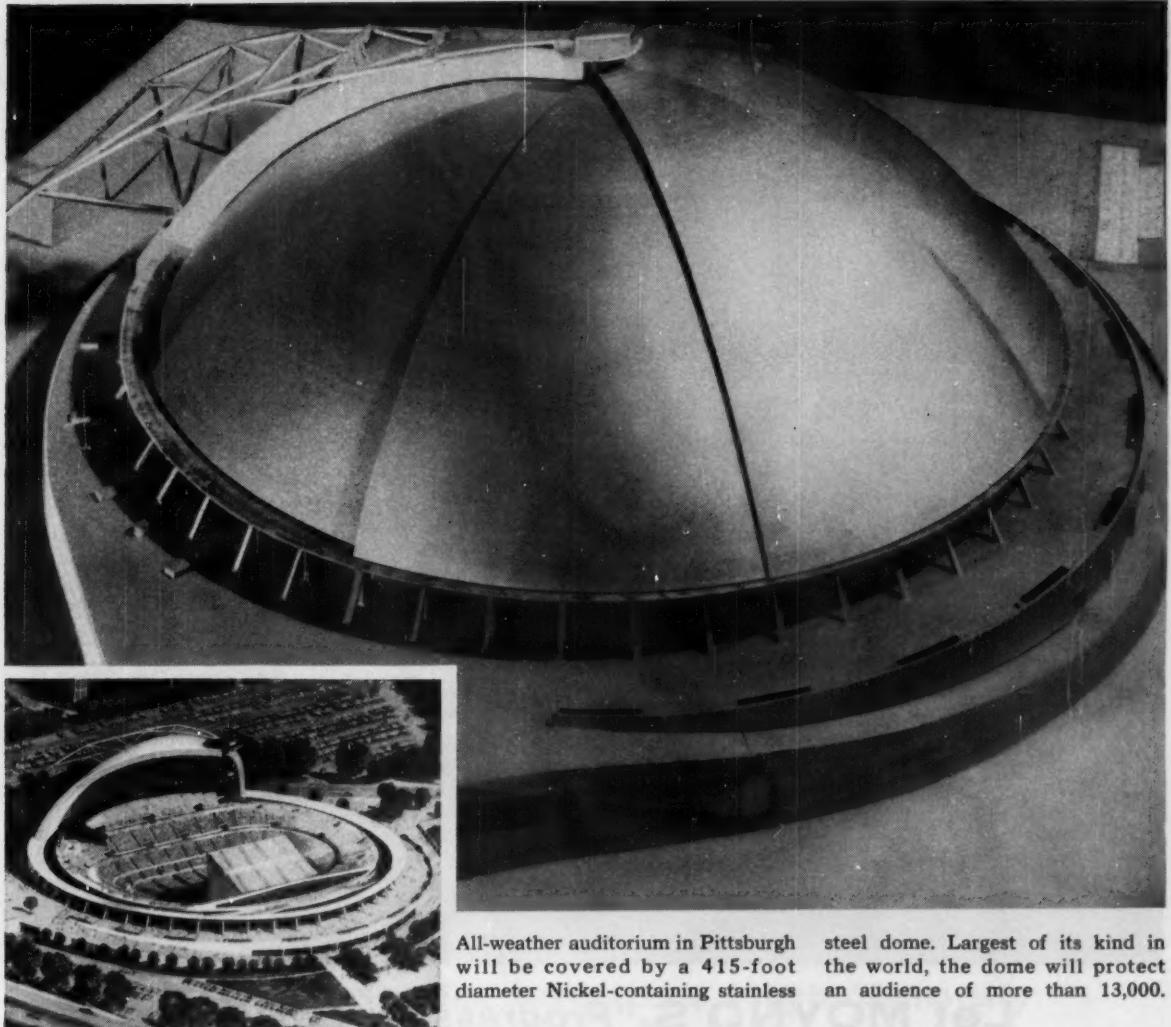
Take the single-row deep-groove ball bearing featured here, as an example. **SKF** designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard **SKF** ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from  $\frac{5}{8}$ " to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

But why not find out what **SKF** offers in bearing quality, availability and economy? Just call the **SKF** branch office nearest you.

6001





All-weather auditorium in Pittsburgh will be covered by a 415-foot diameter Nickel-containing stainless

steel dome. Largest of its kind in the world, the dome will protect an audience of more than 13,000.

## "Push-button umbrella roof" of stainless steel gives Pittsburgh a new all-weather auditorium

Watching a play or listening to music under the stars heightens the enjoyment. That is, until a passing shower comes along to wash out the fun. But now comes a new idea in auditoriums. In this one, an umbrella roof of Nickel-containing stainless steel will close at the first drops of rain—and on with the show.

It's a simple concept, but a daring one. Eight huge sections nest together when the dome is open. Push a button, and six of these sections glide quietly together around an outside track.

They looked into all sorts of sheathing materials in designing the dome before choosing stainless — a Nickel-containing stainless steel.

For stainless with Nickel in it is one of the most weatherproof metals there is. It is corrosion-resisting all the way through — in salt air as well as industrial atmospheres. What's more, it's virtually self-cleaning — rainfall alone keeps this metal clean.

No wonder you see Nickel-containing stainless wherever strength, long life and handsome appearance

are called for! Not only in buildings — inside and out — but everywhere you look.

**Suggest something to you?** Can stainless help you solve a problem involving corrosion, stress, appearance, temperature extremes? The way to find out is to write us. We'll see if Nickel-containing stainless steel — or some other nickel alloy — may be just what you're looking for.

THE INTERNATIONAL NICKEL COMPANY, INC.  
67 Wall Street  New York 5, N. Y.

**INCO NICKEL**  
NICKEL MAKES ALLOYS PERFORM BETTER LONGER



MOYNO.  
PUMPS

## Let MOYNO'S. "Progressing Cavities" Cut your Pump Maintenance Costs!

MOYNO's unique "progressing cavity" principle cuts pump maintenance costs because material being moved contacts only one moving element. MOYNOS are constructed to stoutly resist corrosion and abrasion. As shown in the cutaway model above, MOYNO's screw-like rotor revolves in a double-threaded stator forming "progressing cavities" that move material smoothly along, without foaming, aerating or crushing. Even where duty is so tortuous that rotor and stator must be made of special resistant materials, MOYNO parts show little wear.

In industry everywhere, and on OEM applications, MOYNOS are proving "if it can be pushed through a pipe . . . MOYNO will pump it!" Typical materials pumped include non-pourable pastes, abrasive slurries, chemicals, foods, acids, even suspended solids up to one inch in size. Many materials now successfully pumped by MOYNO were once considered "unpumpable" . . . had run up prohibitive maintenance costs on other type pumps or ruined them completely.

Capacities are available up to 500 gpm and pressures up to 1000 psi. Off-the-shelf replacement parts are always immediately available. No doubt your plant flowsheet or OEM product has a spot where Moynos can cut costs drastically. To find out how, write today for Bulletin 30 MD.



capacities to 500 gpm; pressures to 1000 psi

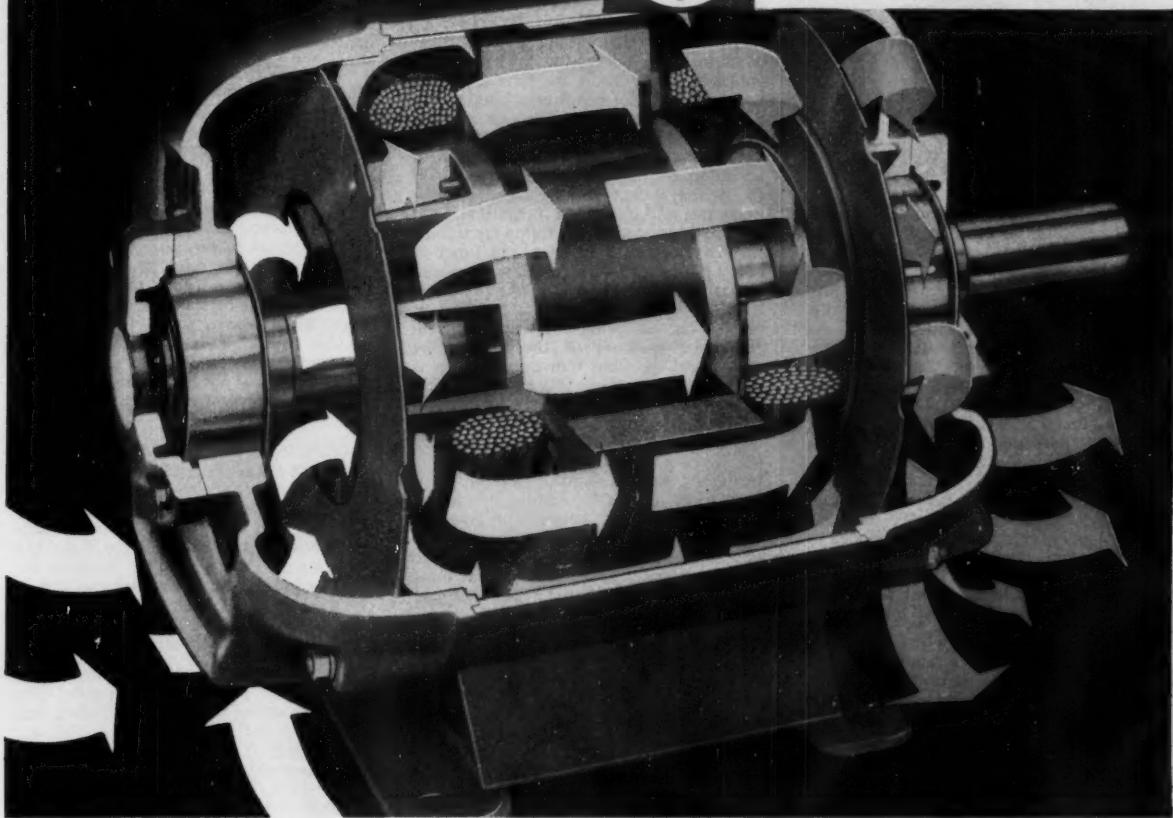
**ROBBINS & MYERS, INC.**

*motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps*  
**SPRINGFIELD, OHIO • BRANTFORD, ONTARIO**



## MOTORS

1 thru 200 horsepower  
(other ratings 1/200 to 1 h.p.)



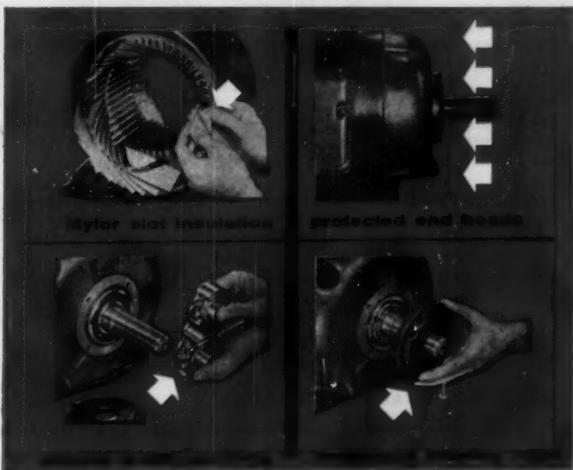
### Longer Life because High Velocity "Dual-Sweep" ventilation Cools and Cleans!

ROBBINS & MYERS "Dual-Sweep" ventilation is a new concept in high velocity internal cooling and cleaning.

ing, designed to greatly prolong motor life. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas and converging air currents which deposit dirt. Venturi baffles at each end of the motor direct air in a washing action over and around end coils where it's most needed. Passages between field and outer shell form a "cylinder of air" which carries off motor heat.

R&M motors' long-life insurance also includes these features: Mylar\* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . double width bearings with extra-large grease capacity . . . end heads that offer full height protection . . . removable caps for quick bearing inspection and re-lubrication. For details, write today for Bulletin 520 MD

\*DuPont registered trademark



**ROBBINS & MYERS, INC.**  
motors, household fans, Propellair industrial fans, hoists, Moyne industrial pumps  
SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

# Secrets of Successful Seal Design

## Fundamentals — No. 1 of A Series



**SPACE** — Around Sealol the bane of our existence is the job which comes to us designed in toto — "no changes allowed. Please fit your mechanical seal into this space". If there isn't space enough, the solution will usually be a compromise with performance standards sacrificed. As an example, a 1" diameter shaft will require a standard Sealol seal with a .531" operating range and a mating ring preferably .250" for a total of .781". This particular seal allows .020" for tolerance stack-up and shaft end motion. But suppose you have allowed us only .700" with a stack-up tolerance of .040"? We may be able to reduce the space required for the seal without sacrificing performance but only if the stack-up tolerance can be reduced to .020". In some cases selective assembly or shimming can produce satisfactory operating life with a bare minimum of axial space. **Moral** — Send us your design before it's frozen.

P.S. Diametrical space requirements do not bother us, but we do urge you to take into account the relative co-efficient of expansion of the stainless steel cup of our seal and the material into which you want it assembled. Sealol's Bulletin #7, Page 6, has some charts which may be helpful.

**CHARACTERISTICS** — In the old days, say ten years ago, you could spot an industrial seal application as distinguished from an aircraft high-performance type of application, a mile away. The former provided for rotation of the axial movable part — the latter invariably provided for these axial movable parts to be stationary in respect to the shaft. Times have changed, but designers generally favor the stationary seal where overall axial space is at a premium since it requires only 40 to 70 percent of the space of a rotary seal. Naturally, they are also much lighter. Furthermore, when shafts start turning at speeds beyond 5000 RPM, springs, pins and assorted hardware have a way of losing their functional abilities and for these situations, the stationary seal is mandatory. On the other hand, rotating seals are usually more rugged in their construction, and they are self-cleaning. They are used extensively on industrial pumps, blowers and compressors. We don't propose to be too dogmatic about the small table shown below, but it serves to delineate our present parameters for stationary and rotating seals.

### MAXIMUM OPERATING CONDITIONS

Stationary Seal	Rotating Seal
-----------------	---------------

Shaft Speed	100,000 RPM — $\frac{1}{4}$ " Dia.	\$5,000 RPM to 3" Dia.
Temp.	-425° to +1000°F	-60° to +450°F
Pressure	2,000 psi	1,200 psi

Note: Maximum conditions indicated do not mean that all are available in a single seal.

Viton-A and Teflon are registered trademarks of E. I. duPont de Nemours & Co., Inc.

90

**PRESSURE** — One of the most critical conditions, but one of the most inconsistent, is pressure. Many times there has been much Sealol head-scratching over a 2 lb. pressure differential in one test rig, whereas pressures in excess of 2000 lbs. were being handled in routine fashion in an adjoining rig. We would be delighted to exchange data with you on pressure phenomena, but in the meantime, you may be interested in the following tidbits. Since operating life of a seal is a function of face load, pressure considerations can be really critical. We design to a unit face-load usually of 8 to 40 psi, depending, of course, on the spring and area involved. Hydraulic pressure of the fluid being sealed and the fluid film pressure across the seal face must also be reckoned with. Around our premises, our engineers banter back and forth a semantic generality called 'seal balance'. If you are interested, ask us for NCIH Paper "Factors in Designing for Mechanical Seal Applications to Hydraulic Equipment". Seal size has a considerable bearing on pressure capability, and as shaft diameters go up into sizes, say above 12 inches and pressures go to 500 psi, seal ring sections become quite massive to prevent distortion. Incidentally, 100 psi is about the maximum pressure we recommend for an unbalanced seal. For higher pressures, we must reckon with interface film destruction resulting from non-balanced face loads.

**SHAFT SPEED** — Top-flight designers are certainly stretching seal performance in many ways. Not the least is your incredible ability to cram into minute space great horsepower performance. This is meaningful to us, because the shaft speeds you now call for are exceeding, in many instances, speeds of 50,000 RPM. Of course, a 100,000 RPM —  $\frac{1}{2}$ " shaft is probably within the capability of existing seals, but from a seal standpoint, the relative surface speed of the seal faces should not exceed about 18,000 FPM under ideal conditions. Irrespective of face

materials, this seems about maximum for full contact and leakproof sealing today.

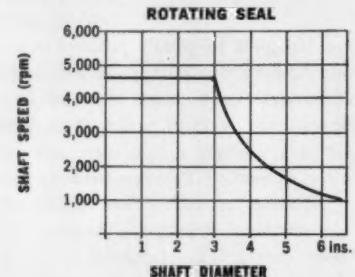
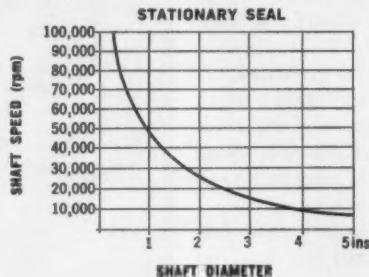
**TEMPERATURE** — As seal designers, our temperature goes up when you ask us for high performance beyond 450°F. ambient. This is about the usable limit for today's elastomers, such as Viton-A and Teflon. However, this too may be misleading. There are Sealol-Flexibox elastomeric packed seals doing a beautiful job in oil refineries with pump temperatures of 750°F. The secret here is, of course, controlled temperature at the seal to produce seal ambients below 450°F. However, within the last two years, Sealol's welded bellows seals are performing well at temperatures to 1000°F. Our thought for the day — if it can't be cooled to within elastomeric limits — consider the all metal welded bellows seal.

**MOUNTING ARRANGEMENT** — If possible, the fluid being sealed should be on the O.D. of the sealing faces. Centrifugal force of any fluid between the faces will then work in your favor to prevent seepage between the rubbing faces. Seals can function satisfactorily with fluid on the inside of the seal faces. We can both avoid long hours on the assembly line later looking for leaks if we arrange matters so that the fluid is on the outside of the face.

**RUN OUT** — We've heard many definitions of run out, but here is ours: The deviation of the plane of the rotating ring from a plane perpendicular to the axis of the shaft. It usually results from a lack of squareness of the rotating sealing surface to the axis of rotation. It causes a wobble of the ring and tends to bounce the seal ring away from contact at high rubbing speeds. For a 2" shaft at 20,000 RPM, run out should not exceed .0005" at the point of contact.

If these thoughts have aroused your interest, write to us with your questions, and we will be glad to elaborate.

The following tables define maximum shaft speeds under optimum conditions.



**SEALOL**  
CORP.

343 Post Road, Providence 5, R. I.

Providence — Stuart 1-4700  
New York — Whitehall 3-9748  
Phil. — Tremont 2-2226  
Chicago — Independence 3-6707  
Denver — Florida 5-7260



Cleveland — Washington 1-7234  
Dayton — Axminster 8-3009  
Houston — Greenwood 2-2318  
Los Angeles — Chapman 5-3746  
San Francisco — Yukon 2-0800

In England: Flexibox Ltd., Manchester

In Europe: Flexibox S.A., 38 Rue de Trevisse, Paris 9  
Flexibox G.m.b.H. Schielestrass 45, Frankfurt/Main-Ost

MACHINE DESIGN



# NEW

General Electric

## DRUM SWITCH

No tools needed to change from maintained to momentary contact



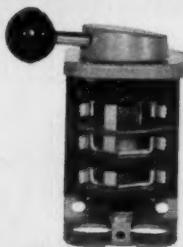
1. Unscrew handle and remove.



2. Lift cap slightly, turn 180°.



3. Reposition cap, replace handle.



**FEATURES:** Compact size • Shock-resistant construction • Visible long-life contacts • Large, easy-to-wire, screw-type terminals • Separate conduit openings for incoming and outgoing leads • Wrap-around cover with 180° accessibility for easy installation.

### Built to last! Easy to install! Reliable "positive-feel" action!

For applications requiring manual control of travel direction, General Electric's new CR102 A1 Drum Switch offers exceptional durability plus convenience features that save installation and modification time.

Rated two hp, 230 volts single-phase and 600 volts polyphase, this new drum switch has a smooth

handle action with solid "positive feel" that machine operators like.

Check the time- and cost-saving features at left. Ask your nearby G-E distributor for GEA-7000, or write to Section 733-51, General Electric Co., Schenectady 5, N. Y.

You get **MEASURABLE ADVANTAGES**  
with General Electric Control

**GENERAL**  **ELECTRIC**

## How Fafnir Ball Bearings help spray dryer manufacturer get

# Reduced bearing costs with no loss in efficiency

In spray dryers produced by a New Jersey manufacturer for the chemical, pharmaceutical, food, and other process industries, a solution or slurry is fed through a hollow, vertical shaft and centrifuged outward into a drying chamber.

The spray is forced into a wheeling vortex by air heated to 200°F to 1000°F. The hot, turbulent air currents evaporate the water and instantaneously transform the solids into powder. The dried products and air pass from the chamber through a duct to a product collector, after which the air is exhausted to the atmosphere.

The driving source of the spray dryer is a high frequency induction motor. The motor armature is located between super-precision ball bearings. Drip feed lubrication is employed at both bearing locations.

At the lower location, an aspirator prevents lubricant from working out into the machine's drying chamber.

During recent redesigning, the manufacturer called on Fafnir to review proposed bearing specifications. The original design incorporated duplex pairs of super-precision bearings mounted back to back.

After studying the loading and service conditions involved, Fafnir engineers advised the manufacturer that single, spring-loaded, super-precision bearings, rather than duplex pairs, would provide the necessary capacity, support, and service life. A similar recommendation was made for a new spray dryer unit then under consideration.

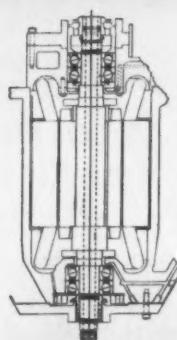
Recommendations of the Fafnir engineers were carried out resulting not only in full operating efficiency, but also effecting substantial savings

in bearing costs.

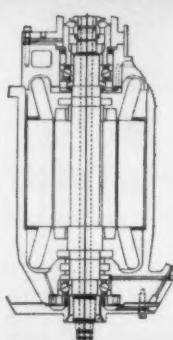
This case history from Fafnir's engineering service files is typical of thousands of ball bearing problems Fafnir has helped solve for manufacturers in every field of industry. For information about the ball bearings described here, or for help with problems you may have, contact your Fafnir branch office nearest you, or write The Fafnir Bearing Company, New Britain, Conn.



**Fafnir Super-Precision Ball Bearing** — Pre-loaded, angular-contact bearings, equipped with composition retainers, are widely used in precision-built mechanisms.

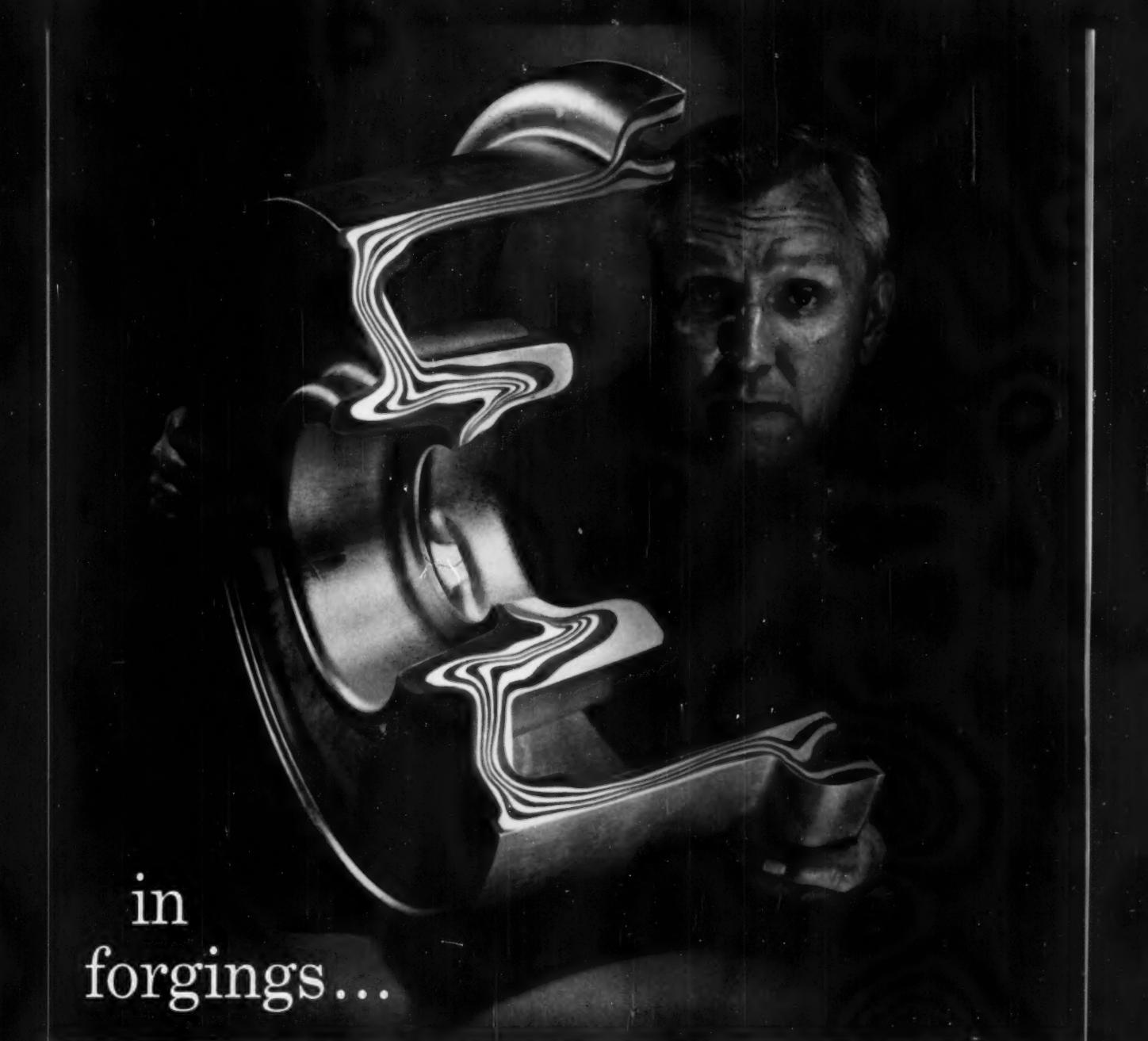


**BEFORE**  
Two duplex pairs of super-precision ball bearings were used to support the high speed shaft of this spray dryer. Redesign specifications called for use of wider type duplex pairs. The change-over was believed necessary for satisfactory shaft support.



**AFTER**  
Fafnir engineers, after a study of loadings and service conditions, advised that a single, super-precision ball bearing at each location would provide ample rigidity. The change resulted in substantial savings at no sacrifice in operating efficiency.

**FAFNIR**  
BALL BEARINGS



in  
forgings...

d'ARAZIEN

## Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow\* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And

Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

\*The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.

*Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.*



For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value.

Thanks to this tiny insulation pin, housewives now get exact temperature control in their cooking appliances because manufacturers are able to design a better product.



## SPAULDING 800 ROD

*Puts More "Skill"  
in Electric Skillets*

It's made of Spaulding 800 Rod material and used in the temperature control dial of electric fry pans.

Spaulding 800's extremely high dimensional stability under heavy moisture conditions helps the dial maintain factory-set temperature calibration and control indefinitely.

800 is another example of a new material developed through the research facilities at Spaulding to meet the changing needs of industry.

Progress Reports on other new Spaulding materials are available on request.



*Spaulding 800 Offers  
These Unique Characteristics*

### SPAULDING FIBRE COMPANY, INC.

345 Wheeler Street, Tonawanda, New York

ELECTRICAL GRADES	XXX-800 (Paper Base)	LE-800 (Linen Base)
Diameter Tested .....	1/4"	1/4"
Water Absorption % .....	.46	.42
Specific Gravity .....	1.35	1.37
Flexural Strength PSI .....	28,000	26,000
Tensile Strength PSI .....	16,700	21,000
Compressive Strength Axially .....	24,000	30,000
Charpy Impact Strength Ft. Lbs. ....	.25	.38



Allen-Bradley offers the

# MOST COMPLETE LINE of oiltight heavy-duty CONTROL UNITS

The wide selection of Allen-Bradley Bulletin 800T push buttons and control units will enable you to satisfy each and every control station requirement. A-B control units and stations have seals to exclude oils and cutting fluids—contacts cannot become fouled. And all control units have the popular A-B double break, silver contacts that assure reliable operation—without maintenance. The rugged construction, flexibility, and generous wiring room of Allen-Bradley's Bulletin 800T line are "bonus" features. To get the best in every way—insist on Allen-Bradley. Send for Publication 6090, today.

**Soft Rubber Boots Prevent Injury**  
to men or machines. A-B pendant stations are available with from 2 to 16 units, plus emergency stop unit in bottom of enclosure.



**ILLUMINATED  
PUSH BUTTON**  
Space-saving two-in-one control unit.



**PUSH-TO-TEST**  
Six different color lenses available.



**POTENTIOMETER UNIT**  
Furnished in 2- or 5-watt capacity ratings.



**4-WAY SELECTOR  
SWITCH**  
Can also be furnished for 2-way operation.



**SELECTOR SWITCH**  
With coin slot operator. Other operators available.



**LOCK TYPE**  
For selector switch or push button operation.



**ENCAPSULATED  
PILOT LIGHT**  
Transformer type for rugged 6-volt bulb.



**TIME DELAY**  
Delay adjustable from 0.5 to 5 seconds.



**DOUBLE CIRCUIT**  
Has 2 N.O. or 2 N.C. sets of contacts.



**16 UNIT  
STATION**  
in die-cast aluminum enclosure.  
Sheet metal cabinets also available for up to 25 control units.

# ALLEN-BRADLEY

Member of NEMA

**QUALITY  
MOTOR  
CONTROL**

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

# Yes, Allen-Bradley also makes...



## DC Contactors

Here's the only line of DC contactors using the simple solenoid design—with ONE moving part—in all ratings through Size 4. And their double break, silver alloy contacts never need servicing.



BULLETIN 202



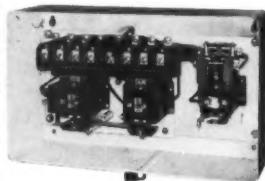
BULLETIN 200



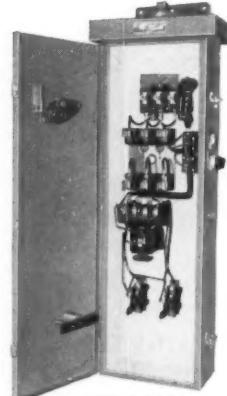
BULLETIN 840



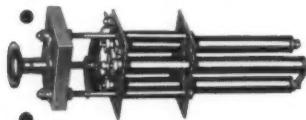
BULLETIN 1209



BULLETIN 1270



BULLETIN 1232



BULLETIN 410

## Loom Switch

Manual starting switches designed for textile loom service. Design of operating lever makes accidental operation impossible. Lint-tight enclosure eliminates fire hazard.

## Automatic Transfer Switches

For use where power must be maintained, these panels automatically transfer the load to an auxiliary supply when normal supply fails or falls too low. Transfers automatically when the normal power supply is resumed. Mechanically interlocked.

## Pump Control Panels

Designed for irrigation and oil field pumping applications. Can also be used with outdoor lighting systems. Uses standard A-B Bulletin 709 solenoid starter with manual disconnect switch or circuit breaker in weatherproof enclosure. Available with many optional features.

## AC and DC Rheostats

Provide absolutely stepless control over a wide resistance range. Full wattage capacity available at all settings. Sizes to 5400 watts.

## Float Switches

This versatile line of float switches is available in a wide range of types and enclosures to handle practically every industrial pumping job. They all feature a snap-action switch mechanism for positive operation no matter how slowly the liquid level changes.

# ALLEN-BRADLEY

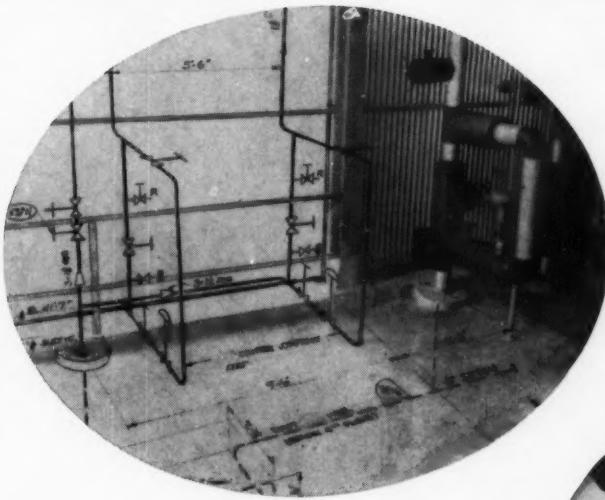
Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

**Quality  
Motor Control**

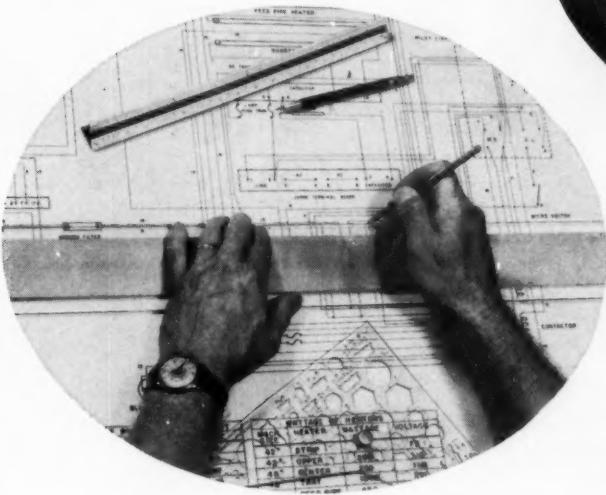


# CRONAFLEX®: best engineering films you can use



## CRONAFLEX: Photographic versatility

CRONAFLEX plus photography plus drafting equals the best combination for photo-drafting techniques.



## CRONAFLEX: Superb drafting surface

Matted on both sides, CRONAFLEX accepts pencil and ink, erases easily without ghosting or affecting the surface.

CRONAFLEX Engineering Reproduction Films are now being used to make outstanding reproductions of engineering drawings in shops everywhere. Shown here are three major reasons that help explain its success. There are more.

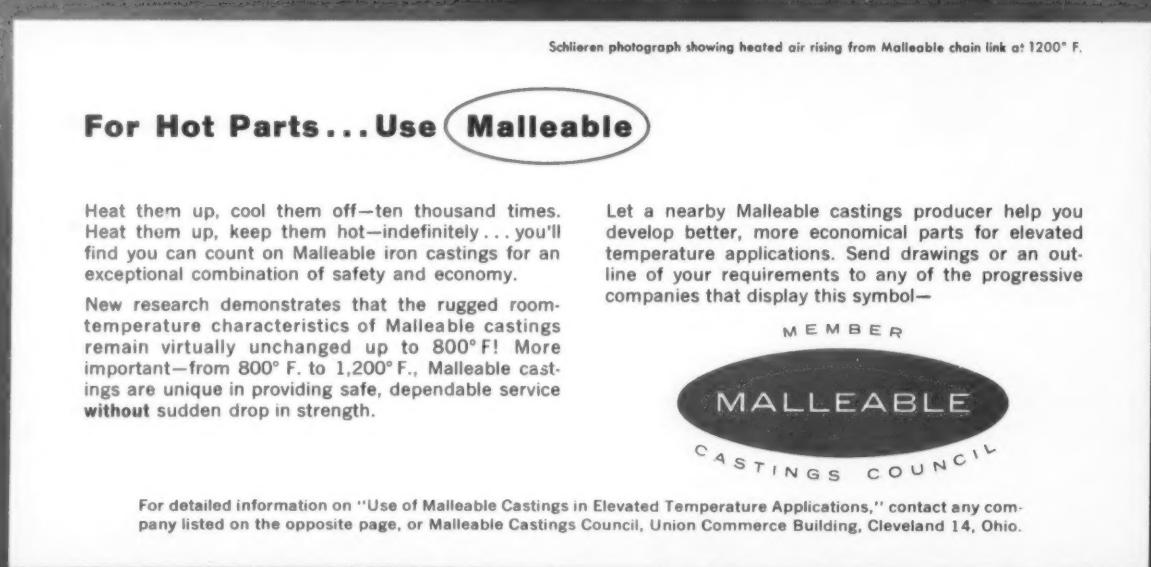
ALL CRONAFLEX films are on rugged CRONAR® polyester base. This means they are dimensionally stable . . . so stable that many companies use them for exacting template work. CRONAFLEX intermediates provide faster print-through speeds and better resolution of detail because of the optical clarity of the base.

CRONAFLEX films are now available in four types: (1) Direct Positive Film; (2) Contact Film; (3) Projection Film; (4) CRONAFLEX Drafting Films. It's the most complete versatile line of engineering reproduction films you can use. For more information, contact your Du Pont Technical Representative, or write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

® Du Pont's trademark for its polyester photographic film base.



Better Things for Better Living  
...through Chemistry



Schlieren photograph showing heated air rising from Malleable chain link at 1200° F.

## For Hot Parts...Use **Malleable**

Heat them up, cool them off—ten thousand times. Heat them up, keep them hot—indefinitely...you'll find you can count on Malleable iron castings for an exceptional combination of safety and economy.

New research demonstrates that the rugged room-temperature characteristics of Malleable castings remain virtually unchanged up to 800° F! More important—from 800° F. to 1,200° F., Malleable castings are unique in providing safe, dependable service without sudden drop in strength.

Let a nearby Malleable castings producer help you develop better, more economical parts for elevated temperature applications. Send drawings or an outline of your requirements to any of the progressive companies that display this symbol—

MEMBER

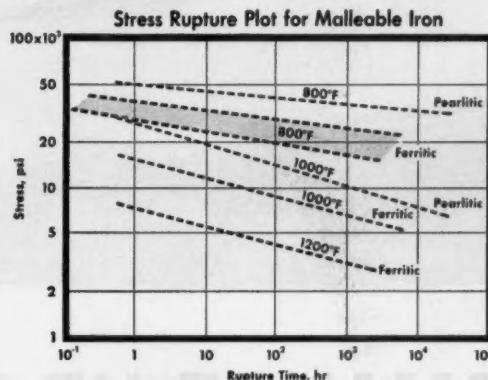


For detailed information on "Use of Malleable Castings in Elevated Temperature Applications," contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

# Get Dependable Strength At Elevated Temperatures With Tough, Economical Malleable Castings

Malleable iron castings give you excellent service under rugged conditions at temperatures up to 800°F. Even at temperatures as high as 1200°F, at reduced stress levels, Malleable castings offer uniformly predictable properties.

Compare these stress-rupture curves for Malleable iron with other ferrous metals. Malleable's are straight, gradually declining curves . . . not curves that break sharply and suddenly downward. With Malleable you can count on long life.



At temperatures from sub-zero to over 800°F, Malleable delivers more strength per dollar than any other metal, ferrous or non-ferrous. In addition, your products will profit from Malleable's exceptional machining ease and uniformity, and the efficiency of the casting process.

**Free Engineering Aid** — To help you more exactly evaluate the possibilities of producing better products at lower cost with Malleable castings, send for *Data Unit 108—Elevated Temperature Characteristics of Malleable Iron Castings*. Your copy is available from any foundry listed below, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.



Eight years of service at 900°F without a failure! That's the history of these pearlitic Malleable conveyor chains carrying aluminum billets through a furnace. Similar Malleable chains have been subjected to temperatures as high as 1300°F in sheet steel normalizing furnaces for years without failure.

Subjected to dynamic stresses at temperatures from 500 to 750°F, these pearlitic Malleable truck and bus diesel engine pistons commonly provide more than 40,000 hours of service . . . over 1,000,000 miles!



## For Quality and Economy... Use

### For Service In Your Area Contact...

#### CONNECTICUT

Connecticut Mall. Castings Co., New Haven 6  
Eastern Malleable Iron Co., Naugatuck  
New Haven Malleable Iron Co., New Haven 4

#### DELAWARE

Eastern Malleable Iron Co., Wilmington 99

#### ILLINOIS

Central Fdry. Div., Gen. Motors, Danville  
Chicago Malleable Castings Co., Chicago 43  
Moline Malleable Iron Co., St. Charles  
National Mall. and Steel Castings Co., Cicero 50  
Peoria Malleable Castings Co., Peoria 1  
Wagner Castings Company, Decatur

#### INDIANA

Link-Belt Company, Indianapolis 6  
National Mall. & Steel Castings Co., Indianapolis 22

#### IOWA

Iowa Malleable Iron Co., Fairfield

#### MASSACHUSETTS

Belcher Malleable Iron Co., Easton

#### MICHIGAN

Albion Malleable Iron Co., Albion  
Auto Specialties Mfg. Co., Saint Joseph  
Cadillac Malleable Iron Co., Cadillac  
Central Fdry. Div., Gen. Motors, Saginaw

#### MINNESOTA

Northern Malleable Iron Co., St. Paul 6

#### MISSISSIPPI

Mississippi Malleable Iron Co., Meridian

#### NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

#### NEW YORK

Acme Steel & Mall. Iron Works, Buffalo 7  
Frazer & Jones Company Division  
Oriskany Malleable Iron Co., Inc., Oriskany

Eastern Malleable Iron Co., Solvay

Westmoreland Mall. Iron Co., Westmoreland

#### OHIO

American Malleable Castings Co., Marion  
Central Fdry. Div., Gen. Motors, Defiance  
Dayton Mall. Iron Co., Ironton Div., Ironton

**MALLEABLE**

Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16  
Maumee Malleable Castings Co., Toledo 5  
National Mall. and Steel Castings Co., Cleveland 6

#### PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22  
Erie Malleable Iron Co., Erie  
Lancaster Malleable Castings Co., Lancaster  
Lehigh Foundries Company, Easton  
Meadville Malleable Iron Co., Meadville  
Pennsylvania Malleable Iron Corp., Lancaster

#### TEXAS

Texas Foundries, Inc., Lufkin

#### WEST VIRGINIA

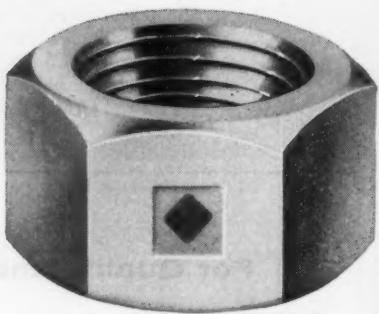
West Virginia Mall. Iron Co., Point Pleasant

#### WISCONSIN

Belle City Malleable Iron Co., Racine  
Chain Belt Company, Milwaukee 1  
Federal Malleable Company, Inc., West Allis 14  
Kirsch Foundry Inc., Reservoir Dam  
Lakeside Malleable Castings Co., Racine  
Milwaukee Malleable & Grey Iron Works, Milwaukee 46



## PERFORMANCE UP...



### ROBERTON MANUFACTURING COMPANY,

Chicago, Illinois, uses 44 Republic NYLOK® Self-Locking Fasteners to hold power units firmly in place in their Roberton Twin Power Riding Mowers. NYLOK'S special nylon inserts assure positive locking in any position. Displacement of the insert produces strong lateral pressure, preventing any play despite extreme vibration.

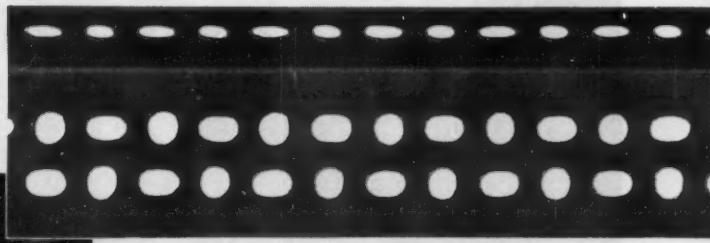
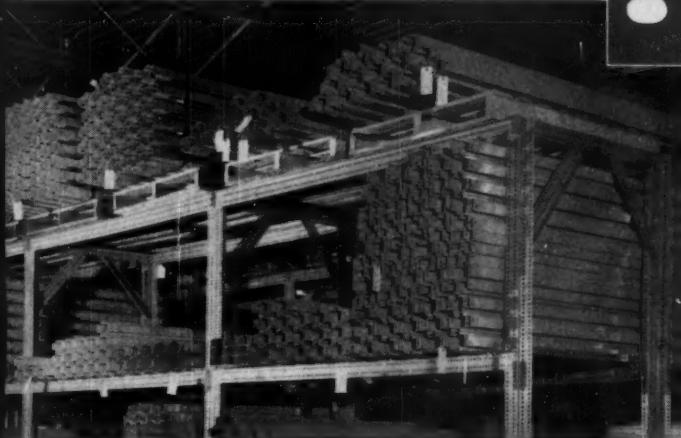
Circle 472 on Page 19



**ACME STAMPING & WIRE FORMING COMPANY**, Pittsburgh, Pennsylvania, uses Republic Type 302 Stainless Steel in the production of tough, corrosion-resistant friction bands for outboard motors produced by Evinrude Motors, Milwaukee, Wisconsin. Used on pivot shafts, the bands measure .062" x 1 $\frac{1}{2}$ ". Fabricating operations include punching, forming in a four slide machine, and brazing on the loop end. According to Acme, ENDURO® Stainless Steel supplied by Republic is exceptionally uniform . . . assures higher product quality at lower unit cost.

Circle 473 on Page 19

## COST DOWN



MORE AND MORE COMPANIES are using Republic METAL LUMBER® to save time and money in meeting storage requirements. Short slots, placed to allow  $\frac{3}{4}$ " vertical adjustment, offer unlimited applications. You simply plan, measure, cut, and assemble. METAL LUMBER is Bonderized. Steel resists damage and permits maximum loading. Send for complete details.

Circle 474 on Page 19



## REPUBLIC STEEL

*World's Widest Range  
of Standard Steels and Steel Products*

**REPUBLIC STEEL CORPORATION**  
**DEPT. MD-8713**  
**1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO**

Please send more information on:

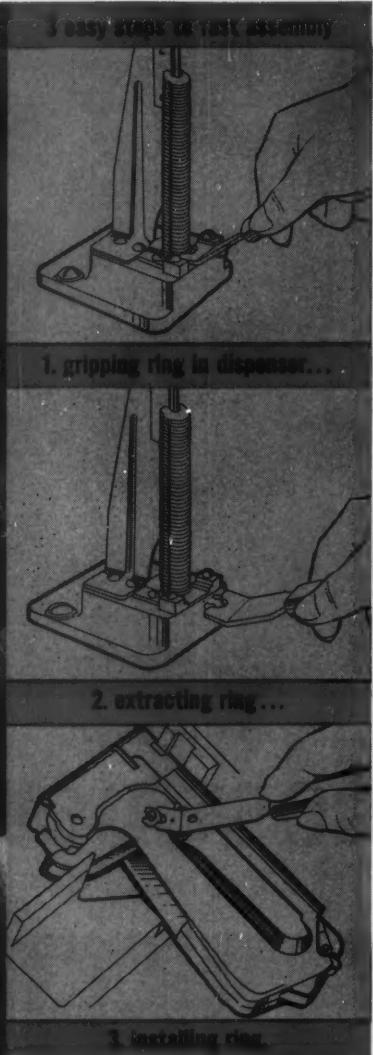
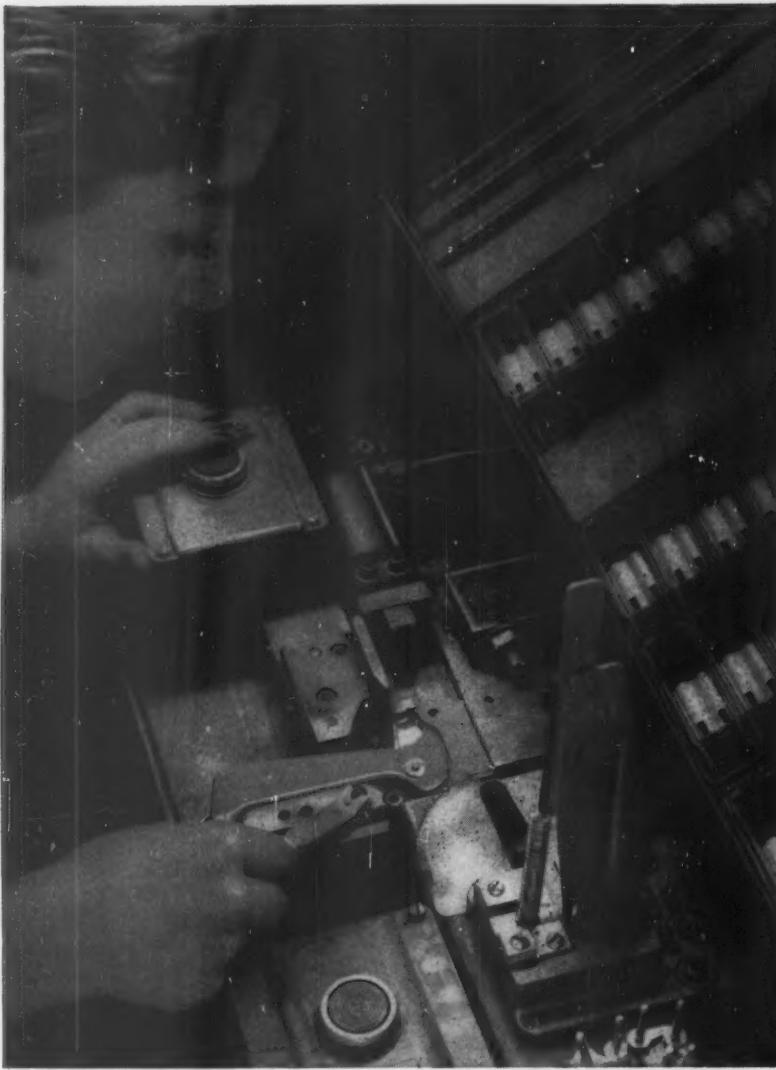
- Republic Stainless Steel
- NYLOK Self-Locking Fasteners
- Republic METAL LUMBER

Name \_\_\_\_\_ Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_



## Truarc rings and dispenser speed staple gun assembly 60%

This big production increase was made by Swingline, Inc., Long Island City, N. Y. in assembling the handle lock of their high-compression staple gun.

To speed production, the Truarc Prong-Lock® Series 5139 retaining rings come *pre-stacked* for use on the Truarc *dispenser* (shown in foreground of photo above). Application is simple, fast and requires no skill. The operator, using the Truarc *applicator*, grasps the bottom ring, removes it from the stack, and installs it, quickly and easily, in the staple gun assembly.

The Truarc ring replaced an ordinary flat "C" washer, previously used in this application. While the unit cost of the washer was lower than that of the Truarc retaining ring, the use of the rings resulted in assembled cost savings of \$25.00 per thousand staple guns. The reasons: a 60% increase in production due to faster, easier assembly with Truarc tools, and the elimination of time-consuming, costly adjustments made possible by Truarc rings. What's more, the bowed Prong-Lock ring improved product design by providing resilient end-play take-up... eliminating looseness or binding in the parts.

Truarc retaining rings come in 50 functionally different types... as many as 97 different sizes within a type... 6 metal specifications and 13 finishes. Truarc assembly tools, pliers, applicators, dispensers and grooving tools are available to speed production of virtually every kind of product. Make sure you have on file the new 16-page Waldes Truarc Assembly Tool Catalog No. AT 10-58. Write for your copy today. And remember Waldes engineers are always ready to help you solve your special application problems. Waldes Kohinoor Inc., 47-16 Austel Place, Long Island City 1, N. Y.

©1959 WALDES KOHINOOR, INC.

9.2

**WALDES**  
**TRUARC®**  
**RETAINING RINGS**  
Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS... THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS



# Flow Sheet<sup>1</sup>

Hoke Reports on Fluid Control

## A VALVE NAMED "DESIRE"

With apologies to Tennessee Williams, we really have produced a Solenoid Valve line based on your desires. We surveyed all the solenoid valve users we could find to determine what you wanted. The result is Hoke's "User Designed" Series 90 and 95, two-way and three-way, direct-acting solenoid valve line.

Thanks to you, we have much to brag about. Here's what we have been saying about these new valves: lightest weight — smallest size — no-hum operation — lowest temperature rise — lowest power consumption — stainless steel plunger — silver AC shading coils — easiest installation — packless construction — 360° rotatable housing — operates in any position.

We make them of forged brass or stainless steel, in  $\frac{1}{8}$ " and  $\frac{1}{4}$ " NPT size or JIC tube ends. There's a variety of AC and DC voltages. Class "A" coils are standard, but Class "H" are also available for temperatures above 212°F. For those with high insurance rates, we can supply explosion proof coil housings.

Now that we've bragged a bit, we must also apologize for our premature enthusiasm. We were so excited about this product that we stirred up a hornet's nest of interest before we were ready to deliver in quantity. Shipments were slow at the start, but now we can have any reasonable quantity of these "desirable" solenoid valves "on-stream" in your plant when you want them.

There's only one way to get conclusive performance proof — buy a valve. Ask for Bulletin SV-1159.



## What Goes With What?

This is a question engineers and chemists are constantly asking each other. Not that we want to do away with this healthy interplay at the water cooler, but we have put together a slide rule that answers all these questions. It lists 22 metals and materials and their degree of resistance to 247 corrosive agents.



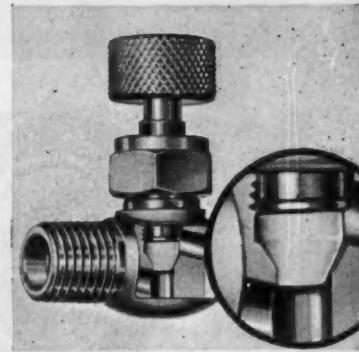
Got yours? Write now while there are a few (thousand) left.

## HOKE'S NEW PLASTIC STEM TIPS END CHRONIC FAILURE PROBLEM

Galling and scoring valve seats plagued valve users and manufacturers for years, until somebody thought of using plastic stem points. This idea worked well at low pressures, but when the pressure increased — poof! — the valve blew its tip. Up to now, this problem had continued to bother valve makers.

Fortunately, a die-hard Hoke engineer insisted he could put a permanent plastic tip on a high pressure valve. We gave him his head and he gave us a plastic-tipped valve-stem (using either Kel-F or Nylon). His unique design incorporates a crimped metal shell that grabs the plastic tip and *really holds!*

Not satisfied with this monumental accomplishment, he proceeded to tackle leak problems at the stem packing. He put an O-ring seal on the stem and compressed it with a newly-designed Nylon collar. The collar serves a dual role, for it also prevents grit and other foreign matter from chewing up the O-ring. Valves of this new design have performed successfully up to 3500 psi. Our die-hard engineer not only



ended galling, but also seat leakage, stem leakage and wear problems — all at one swoop.

There's only one feature about this new development that worries us — since we do not expect replacements we may have designed ourselves right out of the valve business! We make these little dandies of either forged brass, bar stock or 316 Stainless, with  $\frac{1}{8}$ " and  $\frac{1}{4}$ " male connections. Temperature limit is 400°F. For the complete story, write, wire, phone or we'll come see you.

### Hoke "TECH-SPEC"



### 570 SERIES CHECK VALVES

Designed for gas or liquid service at pressures to 5000 psi. Ball and piston types for extremely effective leak-tight closure, coupled with minimum flow resistance. Ball types in  $\frac{1}{8}$ " and  $\frac{1}{4}$ " sizes; piston types in  $\frac{1}{4}$ " and  $\frac{1}{2}$ " sizes. Temperature limits, -40 to 200°F. Body materials are Brass or 303SS. End construction is interchangeable with any combination of inlet and outlet connections. O-ring seals are available.

#### HOKE, INCORPORATED

91 Piermont Road, Cresskill, N.J.

Send me complete information on the Hoke products checked below:

- Plastic Stem Tips
- Solenoid Valves
- 570 Series Check Valves
- FREE Corrosion Slide Rule
- Have a salesman call

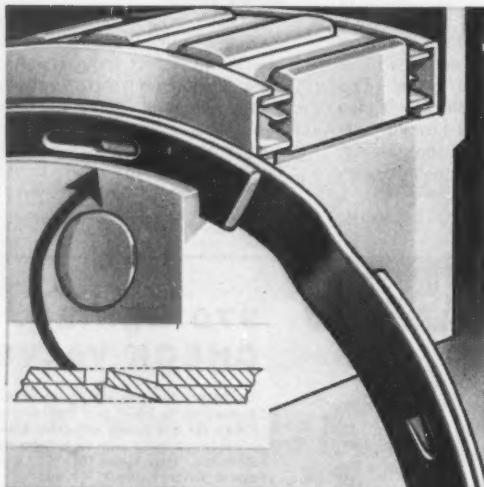
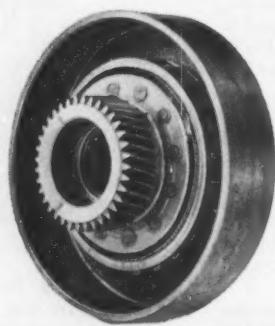
NAME \_\_\_\_\_ TITLE \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_

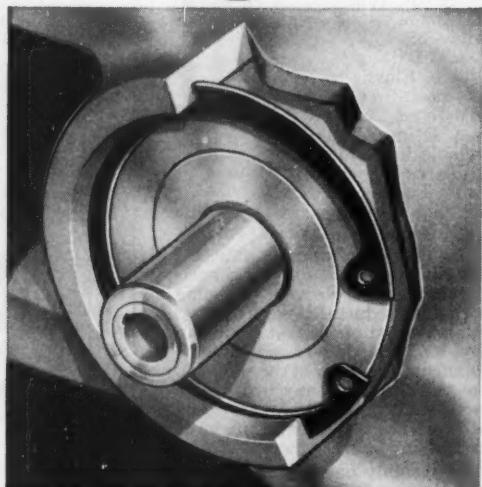
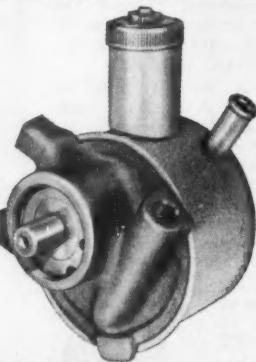
# total 2 gives you the Superior Solution!



## SpirLox

the Superior Solution  
for this GEAR ASSEMBLY used in  
a leading tractor transmission

This exclusive 360° retaining ring in the patented SELF LOCKING TYPE provided the just right answer because it had all these important advantages: (1) full bearing surface; (2) ability to withstand impact; (3) positive prevention of unseating due to centrifugal force.



## CircoLox

the Superior Solution  
for this Power Steering Pump used  
in a leading make automobile

Circolox provided an improved answer to this manufacturer since it allowed for a simplified design and a reduced cost. By using Circolox, drilling and tapping operations and several component parts were eliminated. In addition, the time required to assemble the pump was reduced.

tOtal 2 means that whatever is the best solution to your retaining ring problems—Ramco can provide it. Only Ramco has BOTH types of Modern retaining rings to assure the *right answer every time*.

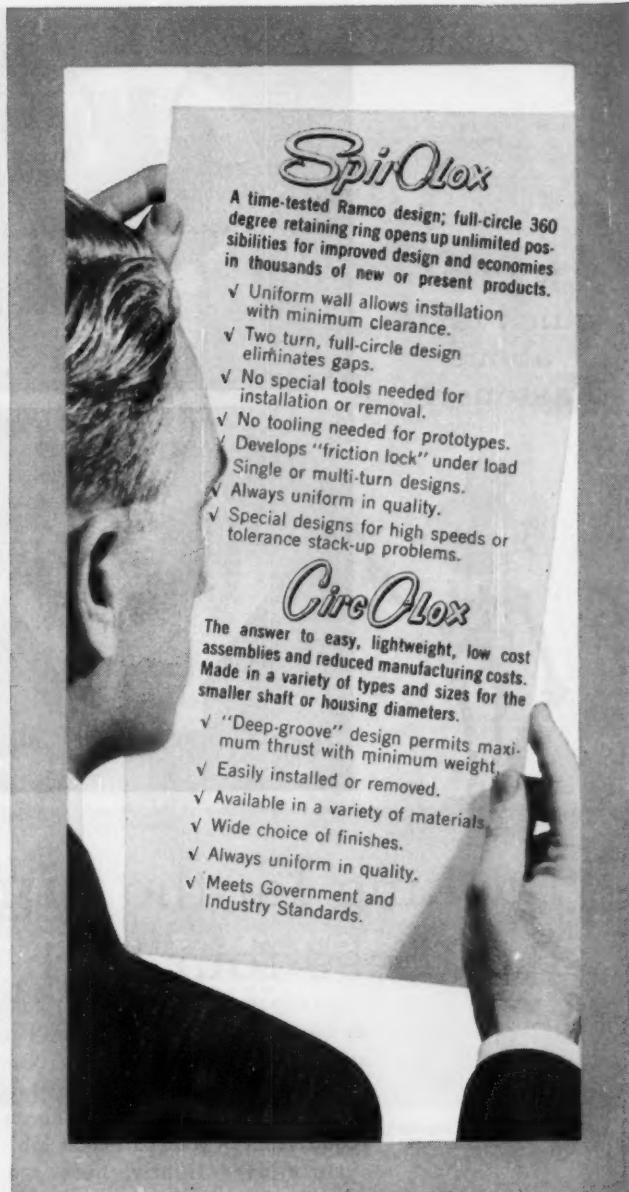
The two applications shown at left are good examples of Ramco's tOtal 2 advantages. No other ring manufacturer could have provided the *right answer* to both of these problems. Ramco Engineers can help you select the one best solution for your design. Free sample retaining rings are available for your use.

The complete story of the tOtal 2 is now brought to you in the new Spirolox-Circolox Engineering Manual and Technical Bulletin Service. These give you all the facts in a simple-to-use form. Included are additional application ideas, design and selection data and ordering information for the variety of materials and finishes available. Your copies will be sent without cost or obligation. Fill in the coupon below and mail today!

# RAMCO t<sup>2</sup>otal

manufactured by  
**RAMSEY CORPORATION**

a subsidiary of  
**Thompson Ramo Wooldridge Inc.** automotive group



**Spirolox**  
A time-tested Ramco design; full-circle 360 degree retaining ring opens up unlimited possibilities for improved design and economies in thousands of new or present products.

- ✓ Uniform wall allows installation with minimum clearance.
- ✓ Two turn, full-circle design eliminates gaps.
- ✓ No special tools needed for installation or removal.
- ✓ No tooling needed for prototypes.
- ✓ Develops "friction lock" under load  
Single or multi-turn designs.
- ✓ Always uniform in quality.
- ✓ Special designs for high speeds or tolerance stack-up problems.

**CircOlox**  
The answer to easy, lightweight, low cost assemblies and reduced manufacturing costs. Made in a variety of types and sizes for the smaller shaft or housing diameters.

- ✓ "Deep-groove" design permits maximum thrust with minimum weight.
- ✓ Easily installed or removed.
- ✓ Available in a variety of materials.
- ✓ Wide choice of finishes.
- ✓ Always uniform in quality.
- ✓ Meets Government and Industry Standards.

IT TAKES 2 MODERN TYPES OF  
**retaining rings**  
TO SOLVE ALL YOUR PROBLEMS

**RAMSEY CORPORATION**

Box 513, Dept. B, St. Louis 66, Missouri  
without obligation please

- Send Free Engineering Manual.
- Enter my name on complimentary subscription list for Technical Bulletin Service bringing the latest retaining ring solution ideas and applications.

Name..... Title.....

Company.....

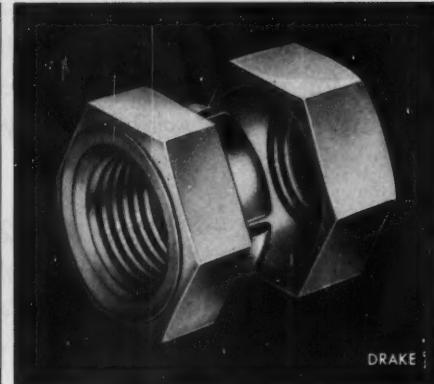
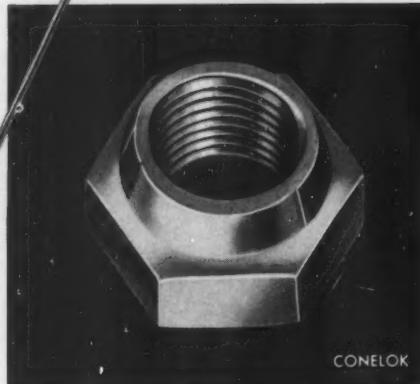
Address.....

City..... Zone..... State.....

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NAT'S  
quick facts  
about  
Fasteners...



## Looking for the **right** lock nut? Put these four high on your check list

By taking an early look at these National all-metal lock nuts, you may often be able to make quick work of finding the locking member that best meets the requirement of your particular job.

Once over lightly, here are the advantages they offer you.

**MARSDEN**—For minimum cost and average conditions. Free-running until seated. One-piece, fully re-usable.

**HUGLOCK**—For use under adverse conditions. Locks without seating. One-piece design, and fully re-usable.

**CONELOK**—For applications requiring high-fatigue life, as assured by closed stress paths in Conelok's locking sections. Locks without seating. One-piece design, and fully re-usable.

**DRAKE**—For use under severe stress, shock or vibration. Free-running until seated, or can be locked at any point by using two wrenches. Two-piece design, and fully re-usable.

Take a good look at all four, and at the advantages they may be able to offer in your product assemblies. You may not be thinking of an application right now, but get the literature\* and keep it handy in your files, just in case.

\*There's a folder on the Conelok, and a booklet on the others. Write for your copies.



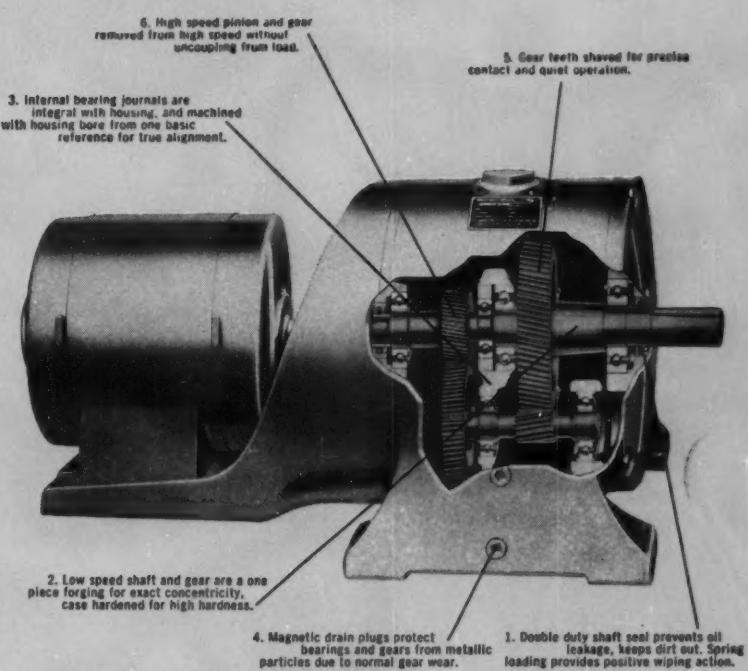
The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

*on the long run...*

**QUALITY COSTS  
YOU LESS!**

And some of the features illustrated here tell why. Accurate tooth loading through precise gearing, freedom from distortion under load and accessibility from either end are a few of the reasons why the Western Gear StraitLine Gearmotor is considered a standard of quality wherever it goes. Your nearby Western Gear sales engineer is ready to supply you with additional information for your next application. And for a starter, use the coupon in this ad to get our basic bulletin No. 5806-F.



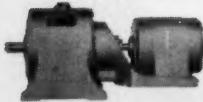
MAINTAIN HIGH PRODUCTION WITH  
THE WESTERN GEAR FAMILY OF  
**STRAITLINE** GEARMOTORS



WESTERN GEAR CORPORATION  
Industrial Products Division  
P.O. Box 126, Belmont, California

*Send me Bulletin 5806F*

NAME \_\_\_\_\_  
TITLE \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ STATE \_\_\_\_\_



SHOVEL-BASE  
GEARMOTOR



VERTICAL  
GEARMOTOR



INTEGRAL  
GEARMOTOR



SHOVEL-BASE REDUCER  
WITH RIGHT ANGLE HEAD



STRAITLINE  
SPEED REDUCER



# SMOOTH, “CUSHION” START

## with new Century Electric part-winding start motor

This new motor . . . at either 1200 or 1800 rpm's . . . will give you smooth, “cushion” acceleration. No cogging, jerking or jarring equipment. No sub-synchronous stalling. Just dependable torque with the same 40% reduction in starting current of all Century Electric part-winding motors.

**New winding**—A special winding scheme makes this extra smooth start possible. Special cross connections are made between coil groups of the basic motor winding. Result: balanced stator field on first step position . . . no cogging . . . smooth acceleration. Means that now motors will give better performance on part-winding start. Also, more time can be taken for acceleration because the winding does not go “across the line” until the rotor has reached a higher speed.

**Applications**—Have an application where power company restrictions limit inrush current? The complete line of Century Electric part-winding start motors is the answer. They provide the most economical and dependable way of starting equipment with low-starting torque such as fans, blowers, centrifugal pumps, and compressors, as well as reciprocating compressors equipped

with unloading valves. And with new Century Electric part-winding motors heavier loads than ever before can now be brought smoothly up to speed.

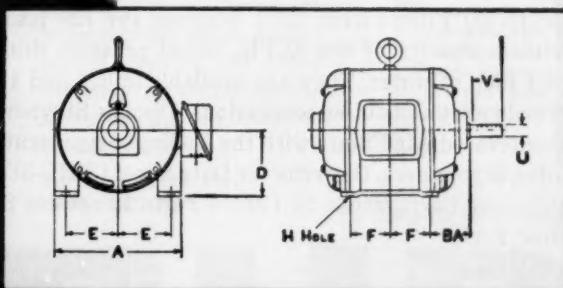
**Construction**—Century Electric part-winding start motors are available in approximate range of 20 to 150 hp sizes and in speeds of 1200 and 1800 rpm. They all have the high quality construction features of all Century Electric squirrel cage induction motors . . . coils are insulated with tough polyvinyl acetal resin . . . windings are dipped and baked with several coats of high temperature synthetic varnish which protect against oil fumes, mild acids and dust and grit . . . rotors are dynamically balanced so that motors run with extreme quietness and smoothness . . . rugged cast iron frame construction assures long life and low noise level.

**Application aid**—A Century Electric application engineer will be glad to discuss your part-winding start problems with you. Century Electric also makes a complete line of motors . . . all sizes and types from 1/20 to 400 hp. For a copy of the new Century Electric Motor Application Guide, please write for bulletin 270A.

### CENTURY ELECTRIC COMPANY

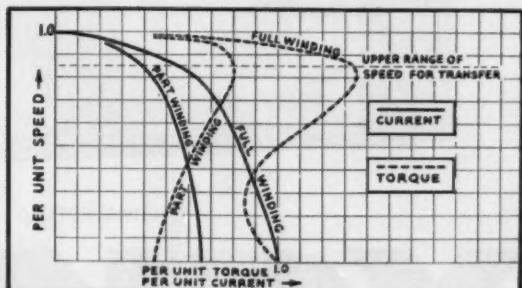
St. Louis 3, Missouri Offices and Stock Points in Principal Cities

*Century*  
59-10



TYPICAL 30 HP part-winding start motor dimensions

Frame Size	Key	A	B	D	E	F	H	U	V
SC 326U	1/2 x 1/2	16	5 1/4	8	6 1/4	6	2 1/2	1 1/8	5 1/8



SPEED-TORQUE curves show how transfer to full winding can be made at higher speed after current has fallen off.

Circle 480 on Page 19



SPECIALISTS  
FOR 39 YEARS

**Filters for  
compressed  
air lines**

**LOW COST, EFFECTIVE  
REMOVAL OF  
DIRT, PIPE SCALE**



Staynew Model CPHB-5D Filter  
has die cast aluminum base and  
head held together with single  
bolt, washer, and gasket.

**DOLLINGER STAYNEW FILTERS** for compressed air lines combine low cost and top filtering efficiency with a compact, easy-to-work-with design. They are small (5 $\frac{1}{4}$ " high, 4 $\frac{1}{2}$ " diameter) for convenient handling and installation . . . can be opened for inspection and cleaning by simply removing one bolt. Staynew Model CPHB-5D Filters have been designed for 125 p.s.i. with a capacity of 600 SCFH, initial pressure drop of 1 inch of water. They are available in  $\frac{3}{4}$ " and 1" female inlet and outlet connections. Discuss Staynew Compressed Air Filters with the Dollinger representative in your area. Or, write for Data Sheet CPHB-5D. Dollinger Corporation, 26 Centre Park, Rochester 3, New York.



**DOLLINGER**

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOSITY PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

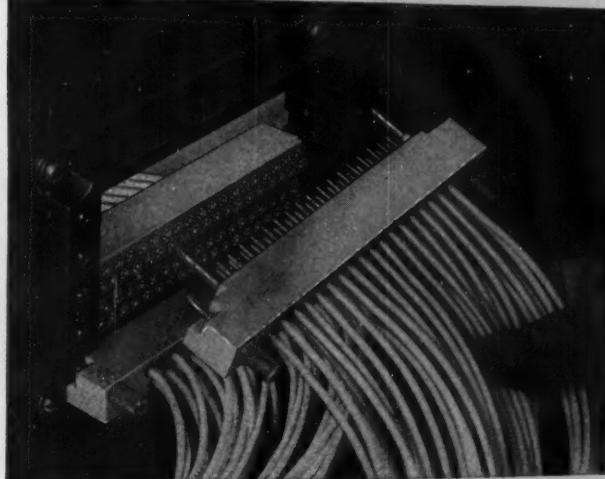


feed-thru,  
multiple  
insert

### **HYFEN® connector**

with crimp-type,  
snap-locked  
contacts

Makes possible  
the design of  
lighter and more  
compact equip-  
ment. Each insert  
holds 35 contacts.  
Frames available  
for 5 or 8 inserts.



*crimp-type*

## **MODULAR ELECTRICAL CONNECTORS**

**IN 3 NEW BASIC TYPES**

Modular units by Burndy provide versatile, rapid and reliable answers to the problem of connecting a multiplicity of wires in relatively limited spaces. Crimped contacts—installed with any of several hand, pneumatic, semi-automatic or automatic tools—can be removed, re-inserted or replaced, providing the most complete flexibility in the connector field. Computers, ground-based radar, missile ground controls, and instrumentation are typical applications for Burndy modular connectors.

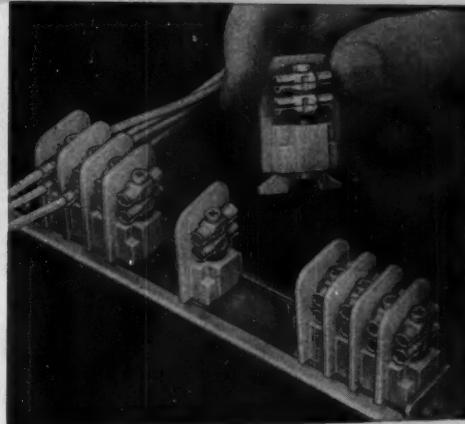
See more at IRE Show  
Booths 1329-1331

quick-disconnect  
or permanently  
connected

### **MODULOK® terminal block**

with snap-in,  
spring-loaded  
contacts

True versatility in a  
terminal block. 30  
modules (2 or 4 tier)  
per foot. Twist of a  
screwdriver transforms  
quick-disconnect con-  
tacts to permanent  
connections.



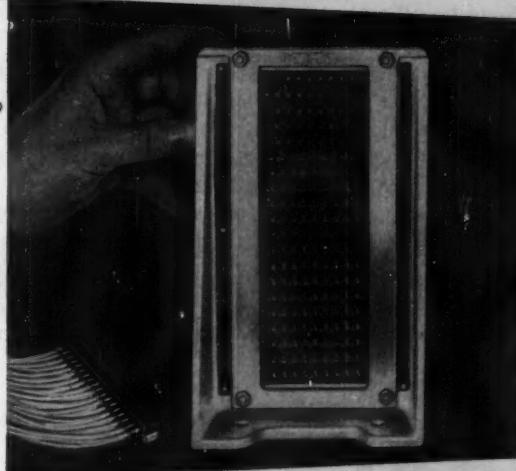
\*Trade Mark

crimp-type,  
solid-shank

### **STAPIN®**

taper pin  
contacts

An other  
Burndy contri-  
bution to the  
modular con-  
cept of assem-  
bling standard  
units to pro-  
vide custom-  
fitted end  
products.



For complete information, write: OMATON DIVISION

# **BURNDY**

Norwalk, Connect.

In Europe: Antwerp, Belgium

58-24

Toronto, Canada



## How are they doing down on the farm?

Nowadays they're doing everything a lot easier, thanks to modern power-operated farm machinery.

And farm machinery producers have learned that their lot can be a lot easier, too, when they specify Ostuco Tubing. That's because there's no compromising with custom-quality Ostuco Tubing. Consistently you receive the exact tubing you want — the size, length, grade — with the strength and tolerances you need. For machined parts, you get our recommended rough size guaranteed to clean up.

In addition to these advantages, Ohio Seamless will fabricate tubular parts to your specification. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.

A-1558A

Model illustrated built to 3.5 mm scale.



Complimentary Copy of new Bulletin CS60 "Ostuco Steel Tubing" sent on request.



## OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

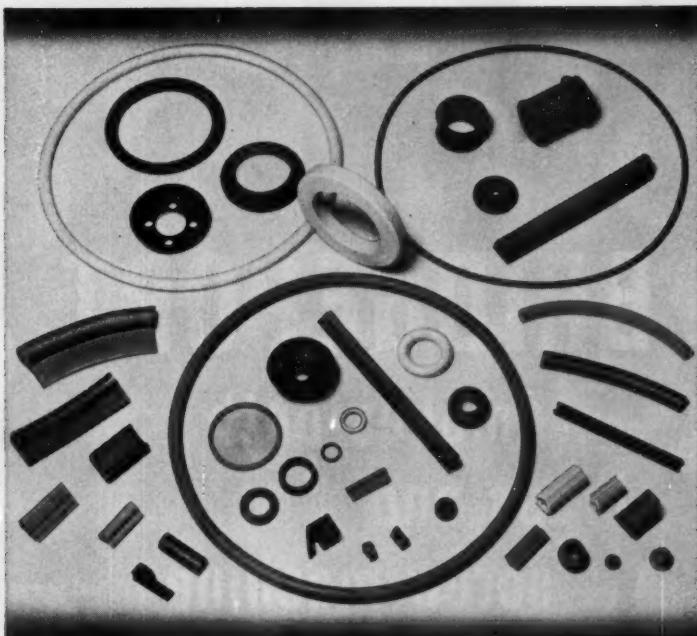
SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Farmington Woods), Houston, Los Angeles (Lynwood), Miami, Malone, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

CABOTIC-CHALMETTE & FARMINGDALE CORP., LTD.

COPPERWELD STEEL COMPANY, 224 Broadway, New York 7, New York



## RUBBER in Design Engineering



### FITTING THE MATERIAL TO THE APPLICATION

No two rubbers are alike. Be sure that, when you design a rubber part, you specify precisely the type of rubber needed for the job involved. Garlock will be glad to offer help, having had years of experience in the engineering and production of molded and extruded, die-cut, and metal bonded parts:

**Natural Rubber**—used where high tensile strength and resiliency are required. Good air-aging properties. Resists dilute aqueous solutions. Applications include automotive air springs, shock mounts, tubing.

**Styrene Butadiene Rubber**—used where resistance to aging is important. Good abrasion, water resistance. Readily available, low cost. Applications include weather stripping, pipe joint gaskets, bushings and grommets.

**Nitrile Rubber**—extremely good oil and gas resistance . . . low solubility, low swelling, good tensile strength, excellent abrasion resistance. Used up to +250° F as oil seals, "O" Ring packing, oil resistant parts.

**Neoprene Rubber**—relatively unaffected by oxidation, weathering, ozone, sunlight, chemicals. Good resistance to abrasion, cutting, chipping. Applications include bridge pads, flexible couplings, spark plug boots.

**Butyl Rubber**—outstanding impermeability to gases, excellent dielectric properties, good resistance to tearing after aging. Unaffected by weather, ozone. Used as hydraulic seals, vibration mountings.

**Garlock also offers** a complete line of specialty rubbers to resist the higher temperatures and more reactive fluids introduced by modern industry and the jet age.

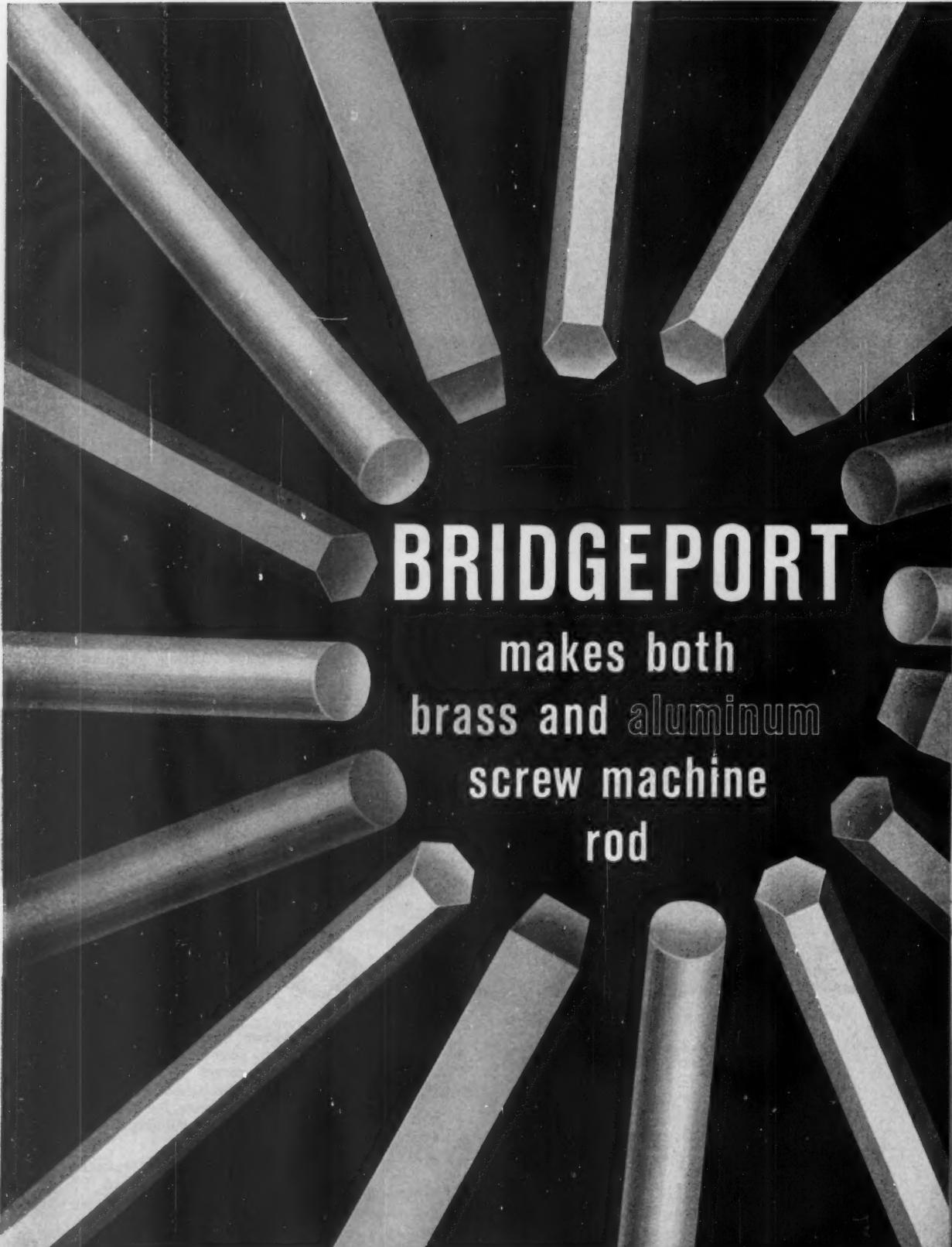
# G A R L O C K

Further information may be obtained from your Garlock representative at the nearest of Garlock's 26 sales offices throughout the U.S. and Canada. Or, write for Catalog AD-167, The Garlock Packing Company, Palmyra, N. Y.

**Canadian Div.:** The Garlock Packing Company of Canada Ltd.

**Plastics Div.:** United States Gasket Company

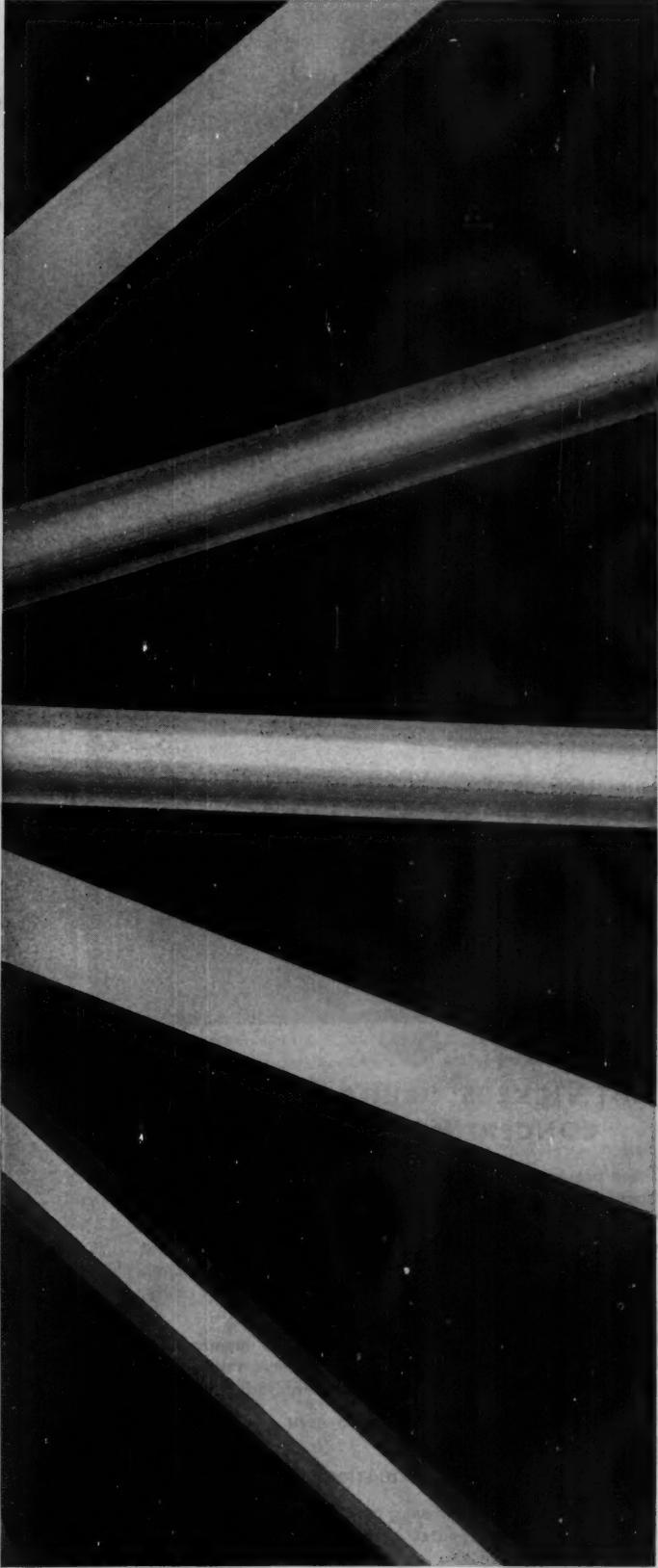
**Order from the Garlock 2,000 . . .** two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products



**BRIDGEPORT**

makes both  
brass and aluminum  
screw machine  
rod

**BRIDGEPORT BRASS COMPANY**



# TIRED OF CONFLICTING CLAIMS ON ALUMINUM vs. BRASS?

The answer's simple...use Bridgeport for your screw machine rod requirements. We make both...know that brass is best for some applications, aluminum for others. That's why you can rely on your Bridgeport Salesman to give you the metal best suited to your specific needs. His recommendation is backed by more than 92 years of Bridgeport metals know-how...and the experience of one of the originators of screw machine stock.

You'll get fast service, too. Bridgeport stocks brass and aluminum screw machine rod—and tube—in warehouses and mills throughout the country for immediate delivery. For full details, call your nearest Bridgeport Sales Office. Or write direct to Bridgeport Brass Company, Bridgeport 2, Conn.

## ALUMINUM SCREW MACHINE ROD

**Advantages:** light weight and low cost—3 times as many pieces per pound; good strength; fine finishing qualities; excellent machinability—low tool wear; high corrosion resistance; non-sparking and non-magnetic.

TYPES	Round and Hexagon.
SIZES	Diameters in 1/64" increments from 1/2" to 3" in standard 12-foot lengths.
ALLOYS	2011-T3 (Standard temper—heat-treated and drawn) 2011-T8 (For applications requiring deep drilling—HT-Drawn-Aged) 2017-T4 (For applications requiring high strength) 6061-T6 (For applications requiring superior corrosion resistance) 2024-T4 (Heat treatable—for applications requiring high strength)

## BRASS SCREW MACHINE ROD

**Advantages:** highest machinability of all—lowest tool wear of all; easiest attainable and most beautiful finish; best corrosion and rust resistance; *highest scrap value*.

TYPES	Round, half-round, oval, square, rectangular, hexagonal and special shapes.
SIZES	Diameters from 1/16" through 4-1/2".
ALLOYS	• Free Cutting Brass • Leaded Commercial Bronze • Tellurium Copper • Sulphur Bearing Copper • Hardware Bronze • Leaded Muntz Metal • Leaded Naval Brass • Aluminum Bronze • Free Cutting Phosphor Bronze • Nickel Silver

**BRIDGEPORT TECHNICAL SERVICE** can help you on all your metals application and fabrication problems... help you reduce costs, improve products, speed production. Ask your Bridgeport Salesman for details. Or write us direct. Dept. 4303, Bridgeport Brass Company, Bridgeport 2, Conn.



Specialists in Metals from Aluminum to Zirconium

an improved  
**VICKERS.**  
**SERVO VALVE**

...yet priced

20% below

previous models

FOR PRECISE CONTROL OF OIL FLOW  
IN INDUSTRIAL, MILITARY AND MARINE  
HYDRAULIC SYSTEMS WHERE HIGH  
RESPONSE, ACCURACY, SIMPLICITY, RUGGED-  
NESS AND DEPENDABILITY ARE ESSENTIAL

Input signal to this improved Vickers electro-hydraulic servo valve can originate from a simple calibrated potentiometer or a sophisticated magnetic or punched tape reader system—yet the result is always extremely precise hydraulic flow proportional to the electrical command. This valve can be applied to a broad array of machine tools, process equipment and ordnance applications and is compatible with the wide range of command input methods commercially available.

There are only four moving parts in the two-stage, spool assembly of the Vickers servo valves, thus providing a simple, contaminant tolerant, exceptionally reliable operation. Get details by writing for Bulletin 59-74.



Available in models for flows to 37 gpm and suitable for operation at pressures to 3000 psi with a choice of mountings.

**VICKERS INCORPORATED**  
DIVISION OF SPERRY RAND CORPORATION  
Machinery Hydraulics Division  
ADMINISTRATIVE and ENGINEERING CENTER  
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Factories also in: Australia, England, Japan and Germany  
In Canada: Vickers-Sperry of Canada, Ltd., Toronto,\* Montreal and Vancouver  
Field Service Headquarters Underlined. Whse. Stock & Repair Branches\*.

**WHAT VICKERS' "BUILDING BLOCK"  
CONCEPT MEANS TO YOU**

These pre-engineered electro-hydraulic servo systems offer positional accuracies of  $\pm .0015$ -inch; and down to  $\pm .0005$ -inch using the same standard components but with additional "trim." Your cost for Vickers "Building Block" systems is far below that normally associated with this degree of accuracy and response. These systems are specifically designed for heavy duty, industrial use.

Plug-in elements make trouble shooting and maintenance easy. Vickers' worldwide service organization insures unmatched backup for your personnel when required.

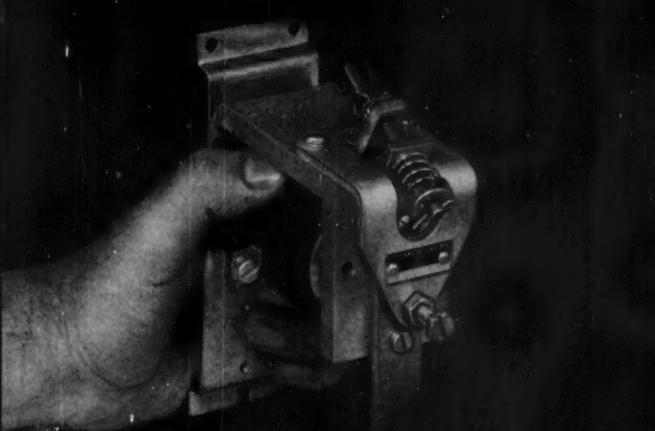
Why not contact the Vickers office near you today for more facts?

**TYPICAL APPLICATIONS**

Controlling velocity in processing applications • controlling position of machine tool slides and tables • programmed control of work handling and machine sequencing.

8479

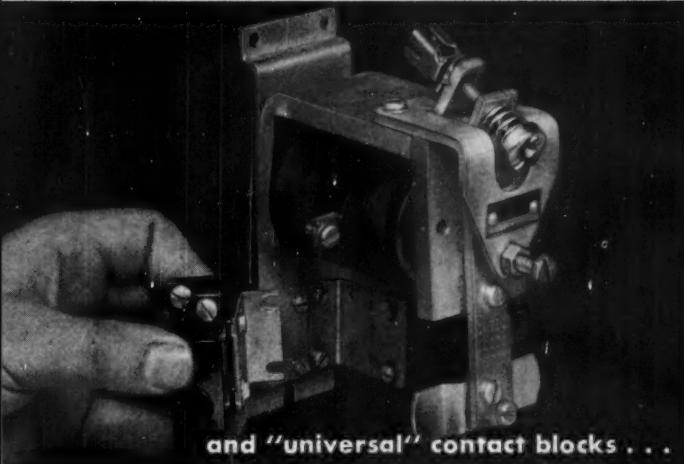
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



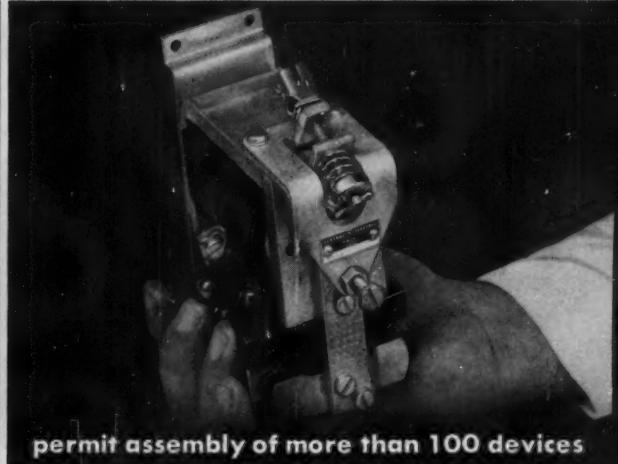
Unit-mounted frame and coil part . . .



with hardware assembly kits . . .



and "universal" contact blocks . . .



permit assembly of more than 100 devices

#### GENERAL ELECTRIC OFFERS

## NEW "building-block" d-c contactors and relays

General Electric's new line of d-c contactors and relays features a new concept in component design—building-block construction. Using front-connected frame and coil parts, standard assembly kits, and "universal" contact blocks, more than 100 different control devices can be assembled. This new design concept makes possible these important cost-saving advantages:

**Reduced inventory**—with building-block design, you need to stock only a mini-

mum number of standard parts. Not only does this mean less costly inventory, but valuable storage space can be released!

**Immediate availability**—with General Electric devices, the contactor or relay you want can be assembled on the spot! No need to order a specific device and await delivery, or stock a large number of special ratings. Assemble what you want—when you want it!

Order today from General Electric's

complete line of stock d-c contactors and relays featuring the new building-block construction.

#### NEED OTHER COMPONENTS?

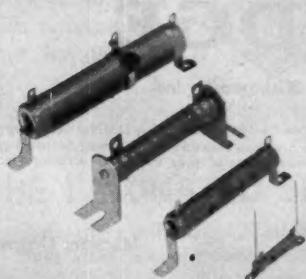
General Electric also has complete lines of plate rheostats and vitreous-enamelled resistors for all your control needs. For more information, contact your General Electric Sales Representative or mail this coupon today! Industry Control Dept., Salem, Va.

**GENERAL**  **ELECTRIC**

Circle 487 on Page 19

**Vitreous-enamelled resistors**—1070 ohmic values from stock, fixed or slide-wire, 5 to 200 watts. Call your G-E representative.

**Plate-type rheostats**—windings are completely encased in metal to give longer and more reliable service for any application.



To: Section B784-25  
General Electric Co.  
Schenectady 5, N. Y.

Please send the following bulletins:

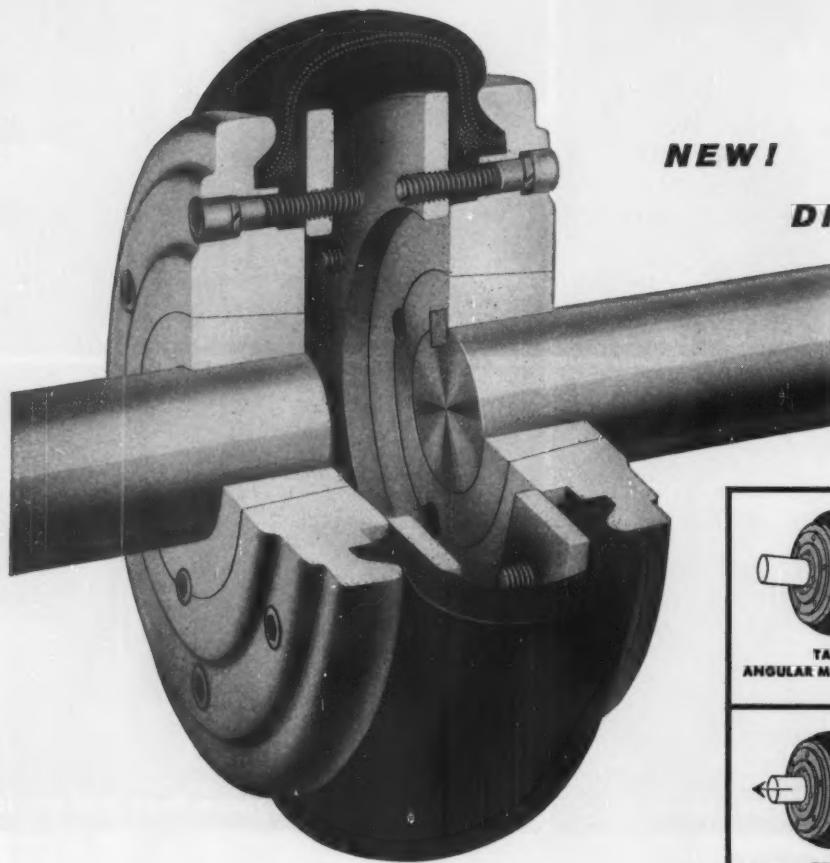
- GEA-6621—D-c contactors and relays
- GEA-6592—Vitreous-enamelled resistors
- GEA-6474—Plate-type field rheostats

Name \_\_\_\_\_

Company \_\_\_\_\_

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**NEW!**

**DIFFERENT!**

**DODGE**

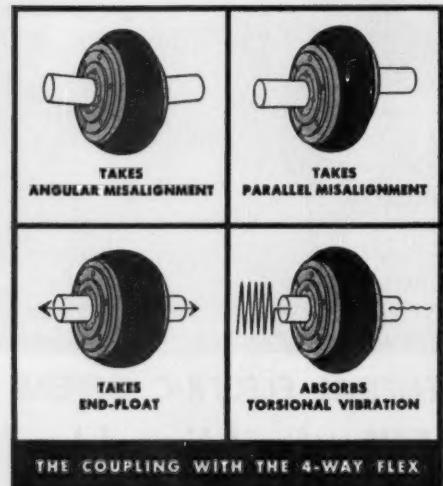
# Para·flex

## FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment or *any combination of all three*. Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding



parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine*.

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 2000 hp at 1080 rpm. Call your distributor for a coupling to *make your own test*. You'll witness something revolutionary!

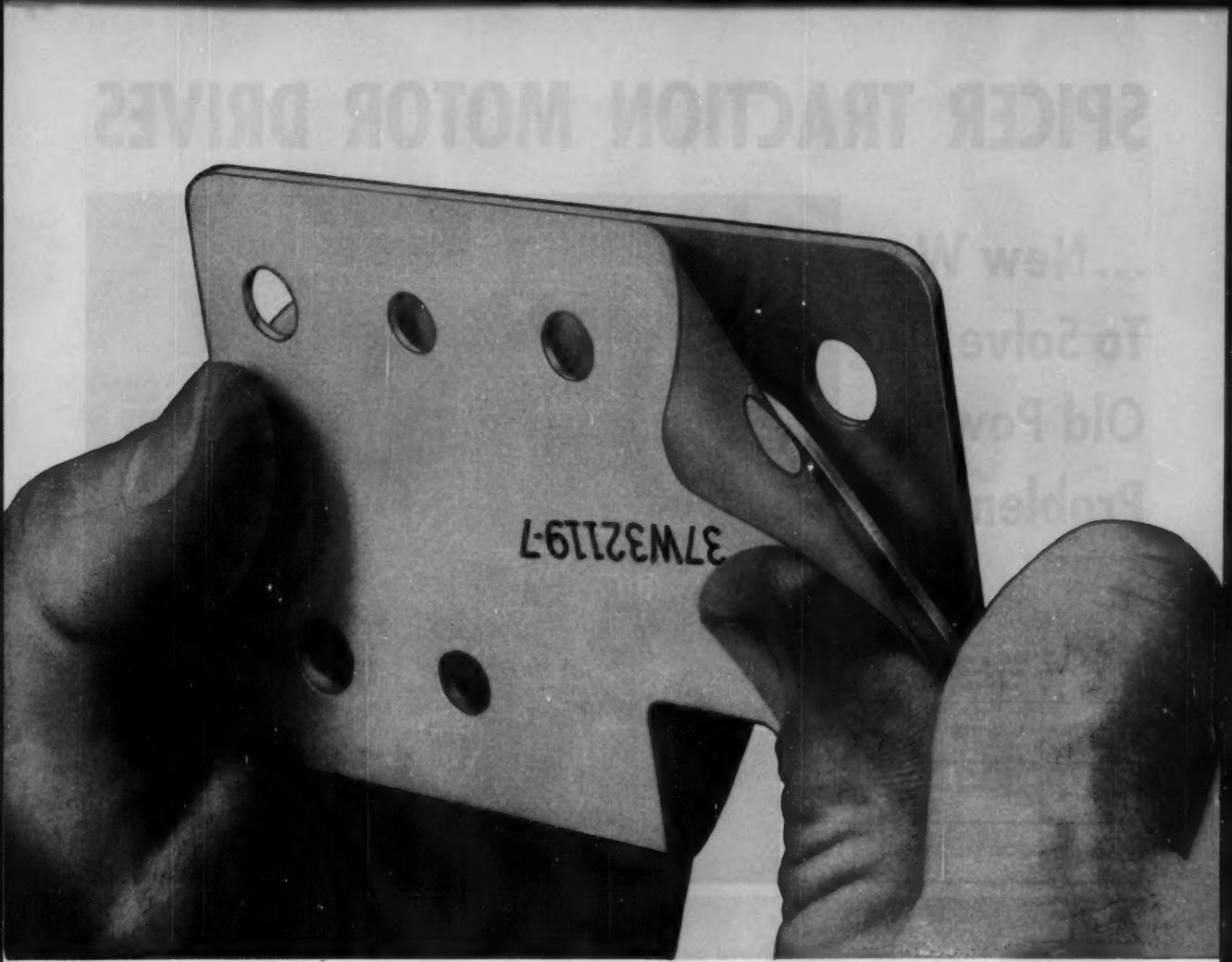
DODGE MANUFACTURING CORPORATION, 3300 Union, Mishawaka, Ind.



**DODGE**

→ of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the white pages of your telephone directory for "Dodge Transmissioneers."



## Simplest, surest way to a "thousandth" fit . . . right at the job

What you see here is a shim. Not an ordinary shim, but a shim of LAMINUM—and that's what makes the difference in convenience, accuracy, speed and economy.

LAMINUM is the registered trade name for the laminated shims whose layers are completely surface-bonded to look and act like solid metal. Yet the laminations are easily p-e-e-l-e-d to bring the shim to any desired thickness for an individual, perfect fit, right at the assembly line.

No stand-by equipment. No machining. No grinding. No counting. No stacking or mixing. And no grit between layers—ever. *That's* what saves time! And cuts costs!

Shims of LAMINUM are economically custom-made to your specifications. In brass, mild steel, stainless and aluminum, with laminations of .002" or .003". For quick service, send your inquiries for information or estimates directly to . . .

### THE LAMINATED SHIM COMPANY, INC.

Home Office and Plant 1203 Union Street, Glenbrook, Connecticut  
West Coast Sales and Service: 600 Sixteenth St., Oakland 12, Calif.  
Circle 489 on Page 19

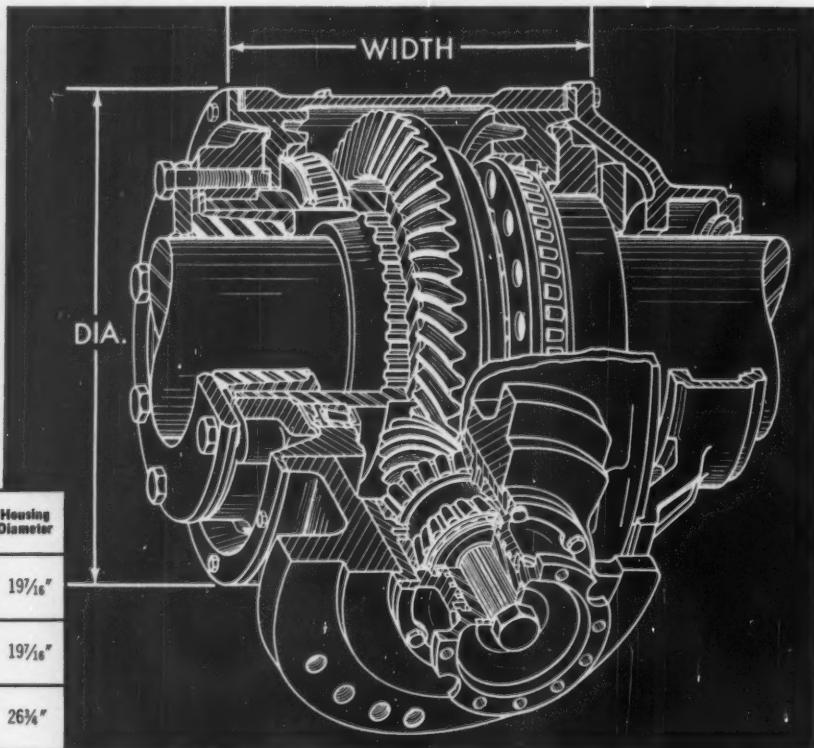


### GET THE FACTS

Write for SHIM DESIGN Folder No. 3—eight pages of up-to-date, well illustrated design information and specifications.

# SPICER TRACTION MOTOR DRIVES

...New Way  
To Solve  
Old Power  
Problems!



	Nominal output torque rating (at wheels)	Housing Width	Housing Diameter
Model 7-5	4,000 ft/lbs	17"	19 $\frac{1}{16}$ "
Model 7-6	4,000 ft/lbs	17"	19 $\frac{1}{16}$ "
Model 8	7,500 ft/lbs	26 $\frac{3}{8}$ "	26 $\frac{3}{8}$ "

Spicer Traction Motor Drives, long preferred by railroads the world over, can be adapted to a multitude of industrial and automotive uses ranging from fork lift trucks to giant earth-moving equipment.

The Spicer Model 7-6 drive illustrated above is similar to the Model 7-5 except that it has been designed to bolt directly to the driving motor through a gear coupling, thus eliminating the propeller shaft.

Both the Model 7-5 and the Model 8 Traction Motor Drives are designed for use with a separate driving motor. Each is coupled by a high-speed, heavy-duty Spicer tubular propeller shaft, dynamically balanced for high speed operation. Universal joints and slip splines are sealed to retain the lubricant and keep out foreign matter.

Spicer Traction Motor Drives have these outstanding design features:

- **Customized Gearing**—all Spicer traction drive units are assembled with matched ring and pinion—based on best tooth combination. You get quieter operation, longer gear life.
- **Slip-Free Drive**—lifetime positive drive is assured by driving through a splined quill and axle collar.
- **Factory-Sealed**—all drive units are completely sealed and tested against oil leaks before shipping.
- **No Field Adjustments Needed**—units are delivered completely assembled and factory-adjusted for bearing alignment and gear setting.
- **Full Cushion Mounting**—drive units are rubber mounted to minimize backlash, protect drive unit from vibration and shock loads.

*For information on how you can fit Spicer Traction Motor Drives into your design plans, ask for your copy of the latest Spicer Technical Bulletin. And ask the Dana engineer for help with your specific problems.*



**DANA**  
**CORPORATION**

Toledo 1, Ohio

SERVING TRANSPORTATION — Transmissions • Auxiliaries  
Universal Joints • Clutches • Propeller Shafts • Power Take-Offs  
Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stamping • Frames • Railway Drives



R/M engineers helped marine transmission manufacturers solve clutch problems for this 55-ft. Chris-Craft Constellation. Twin engines develop up to 550 hp, provide speeds to 23 mph; equipped with newly designed hydraulic aluminum marine transmissions with R/M sintered bronze clutch material.

Photo courtesy Chris-Craft

## How Raybestos-Manhattan helped design clutch for new marine transmission

"The extensive friction material knowledge and experience of R/M engineers save us time and money when we are working on a new design for a clutch or friction part," says Carl Benson, assistant manager and chief engineer, Paragon Gear Works, Taunton, Mass.

### Solve problems on spot

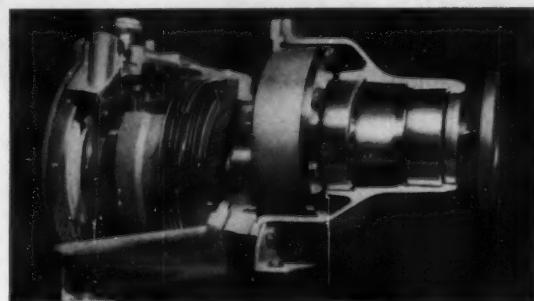
"In developing our new 'H-A' hydraulic aluminum transmission, we took an R/M engineer right with us to our customer's engine plant in Michigan. We solved our clutch problems on the spot.

"Our customers appreciate this extra engineering service we can offer them through R/M. Wherever we are we know we can pick up the phone and have the nearest R/M engineer come to us. We get this extra service, yet prices are competitive; quality is uniformly high."

### Save time, money

You may also be able to save time and money by calling on experienced R/M engineers to help solve your friction problems. You can depend on sound, unbiased counsel on the material best suited for your application—for only R/M manufactures all types of friction materials! An R/M sales engineer can be at your desk within 24 hours.

Send now for your free copy of Bulletin No. 501—packed with helpful engineering information on friction materials.



Advanced-design Paragon "H-A" hydraulic aluminum transmission for Chris-Craft 430 engine which develops 275 hp at 4000 rpm. Clutch is self-compensating; no adjustment ever.



Pencil points to R/M sintered metal clutch facing .015 in. of sintered bronze on .070 in. steel plate. Has a high coefficient of friction in presence of oil; strength to withstand 4000 rpm; precision operation within narrow clearances of .007 to .010 in.



# RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION: Bridgeport, Conn. • Chicago 31 • Cleveland 18 • Detroit 2 • Los Angeles 58

*Designers think of R/M first for asbestos, rubber,*

Special **Ray-BOND** Adhesive

# BONDS GLASS TO PLASTIC



To reduce breakage and assembly time of glass vacuum bottle fillers, The American Thermos Products Company, Norwich, Connecticut, undertook to replace an aluminum cap with a polyethylene protector for the evacuation tip of the glass filler.

The problem was bonding the traction-free polyethylene to the smooth glass surface. Existing adhesives couldn't do the job. R/M adhesives specialists, working closely with Thermos Company engineers, quickly developed a special adhesive.

The result is a superior bonding agent, R/M's new R-84002, for "Mylar," polyethylene, glass and other slick-surface bond-resistant materials. Based on a thermoplastic synthetic resin, R-84002 has temperature tolerances ranging from -20 to +200°F.

Regardless of your application, Ray-BOND adhesives of new or existing formulations can be tailored to your special bonding, laminating, sealing or coating requirement. Your costs are reduced; your production is improved. Let us prove this to your satisfaction. Call on Raybestos-Manhattan adhesives engineers today without obligation.

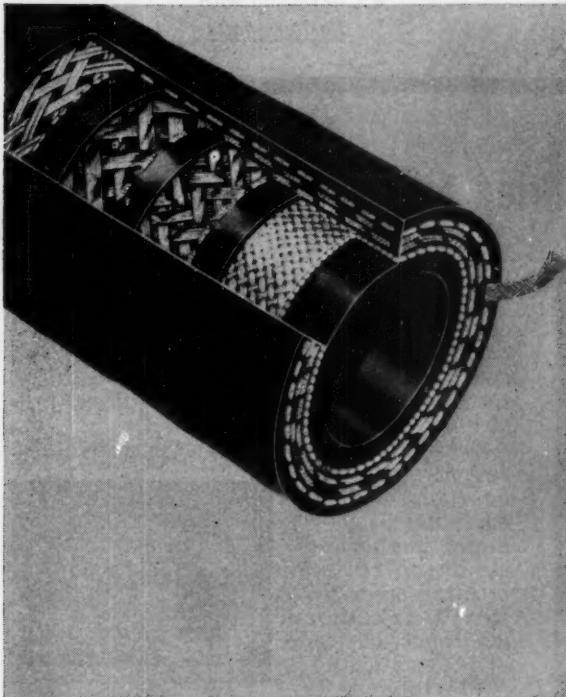
## ADHESIVES



R/M Bulletin No. 700 contains helpful engineering information on Ray-BOND adhesives, protective coatings and sealers, and casting, encapsulating and potting compounds. Write for your free copy today—Adhesives Division, Raybestos-Manhattan, Inc., Bridgeport, Conn.

Circle 492 on Page 19A

# *sintered metal, and engineered plastic products*



## **THE STRENGTH OF STEEL...**

### **In R/M's Non-Burst BW Steam Hose**

R/M offers a full line of precision-built hose for every steam application at saturated pressures to 200 lbs., 388° F. Strength and durability are employed throughout the construction of Super-Master BW Steam Hose, illustrated above. Two braids of high-tensile, multiple end, non-corrosive steel wire are applied at a controlled angle over an asbestos-covered inner tube of thick steam-resistant rubber for greatest strength with minimum elongation and contraction, and provide positive protection against bursting. Cover is of special Butyl rubber to resist heat and weather. Sizes from  $\frac{1}{2}$  to 2 inches.

The strength of steel, the heat resistance of asbestos, the flexibility of rubber, the static dissipating wire, all in Super-Master BW Steam Hose . . . the safest high-pressure steam hose made. Write for Bulletin M630.

## **For temperatures over 1000°F**

**in systems handling superheated steam, gases and oils**  
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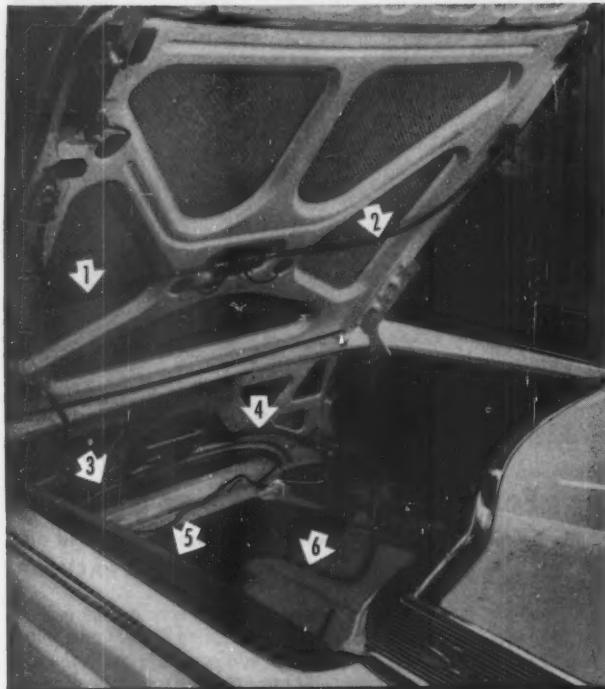


## DRIVE AND CONTROL IDEAS FOR ENGINEERS

- *Tips on better  
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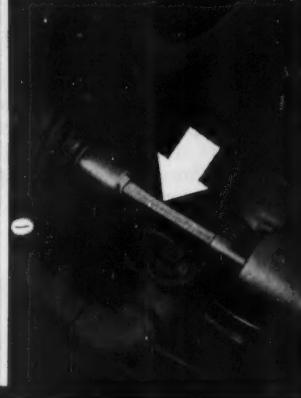
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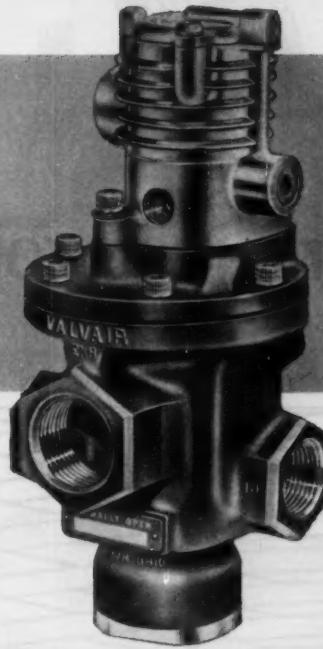
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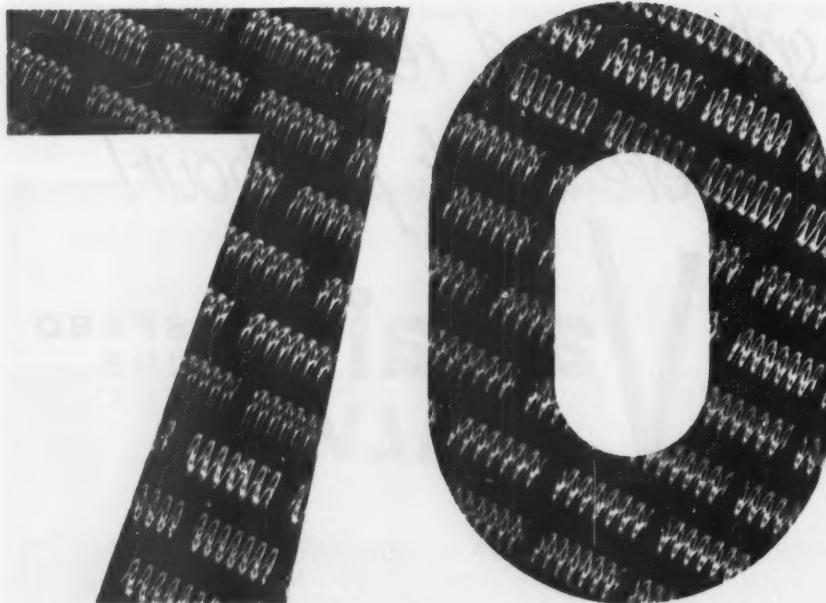
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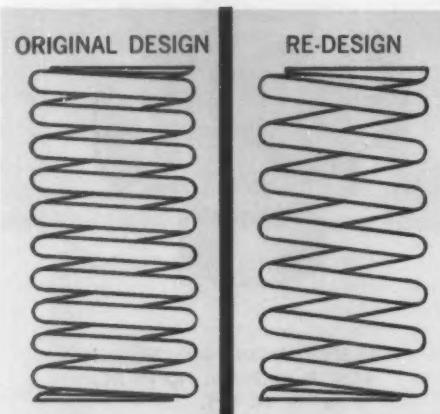


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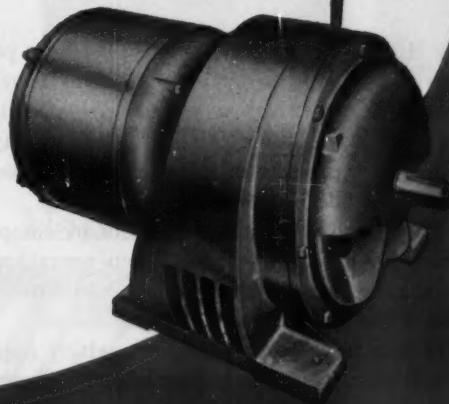
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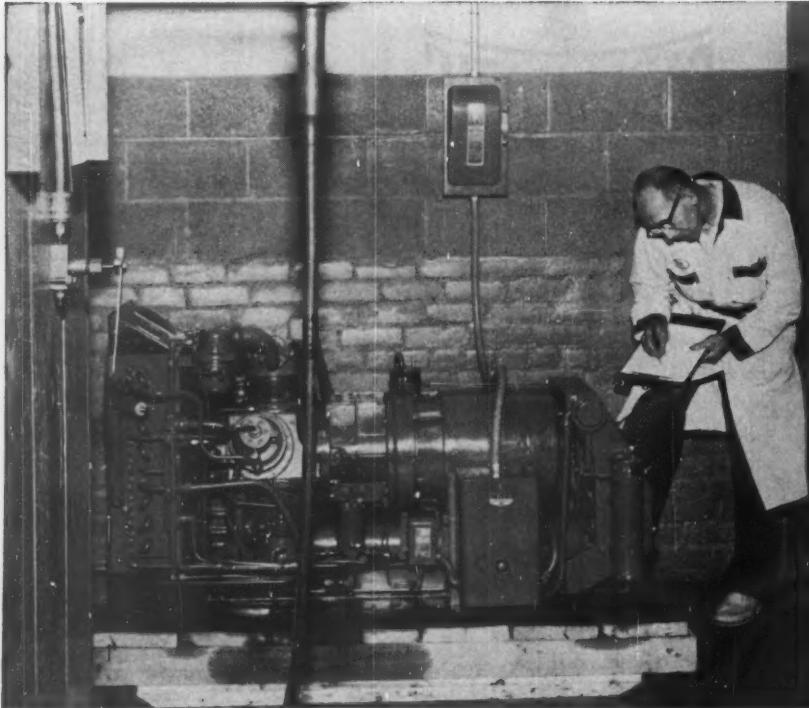
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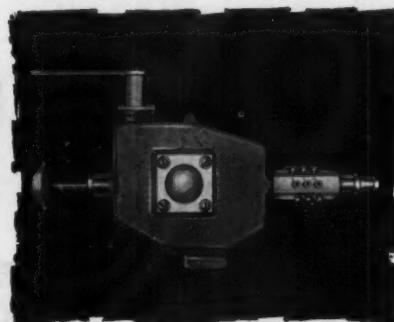
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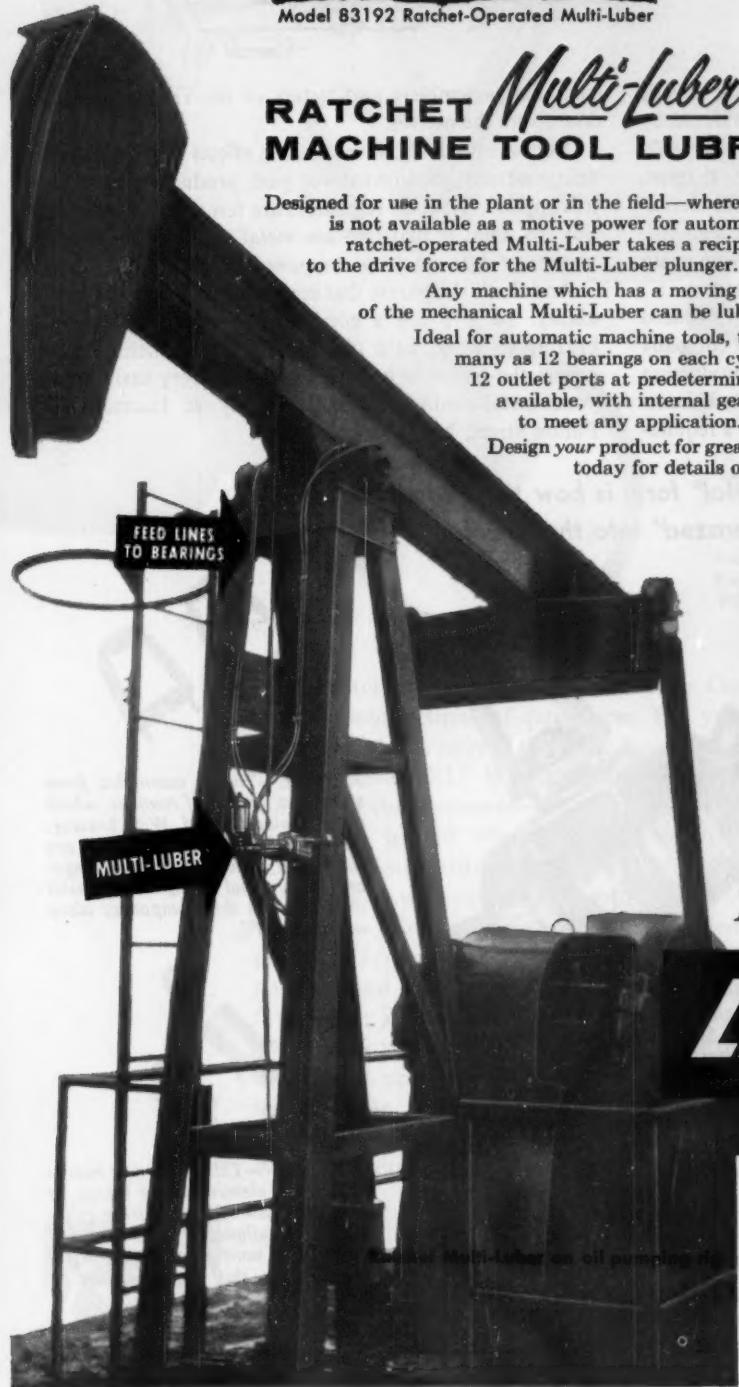
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Perhaps the most vital component of a skin diver's equipment, this Viking Air Regulator, manufactured by Christensen Tool & Engineering Company, Norwalk, Connecticut, is structurally guaranteed for life. It must, under all conditions, be absolutely leaktight. The manufacturer's guarantee is a relatively recent achievement—through the high-strength help of silver alloy brazing with Handy & Harman EASY-FLO 45 and HANDY FLUX.

Over and above the unreserved dependability of brazed joints, the brazing method itself has saved the company considerable time, money and material in the production of the Viking Air Regulator. Brazing's simplicity is interestingly illustrated in this case by this company's require-

ment that assemblers and testers of the Viking must be skin divers themselves.

Almost invariably, silver brazing effects economies and brings advantages to whatever part, product or assembly it is applied. True, air regulators are few and far between, but the point is that they are *metal products, made of a number of different metal components*.

And that's the phrase that covers brazing's great adaptability. To give you a good idea of how you can put brazing to work, we'd like to send you Bulletin 20—it covers the basics of brazing and it may very easily solve your metal-joining problems. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

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**4. PISTON**—This is the most important single element of the Viking. It regulates flow of oxygen from cylinder to mouthpiece; from 300 lbs. pressure to normal breathing. Without brazing, this part could not be made.

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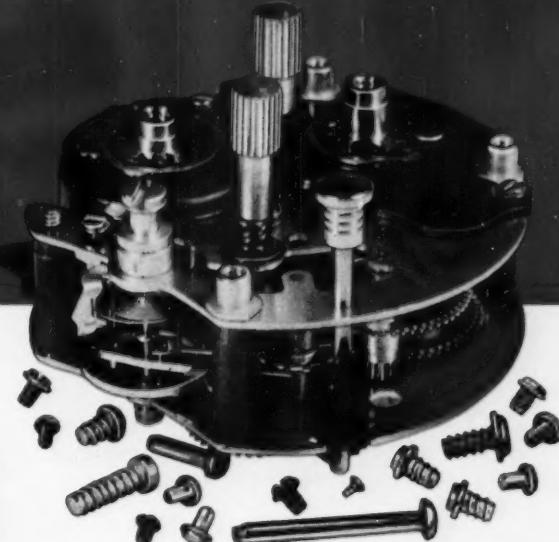
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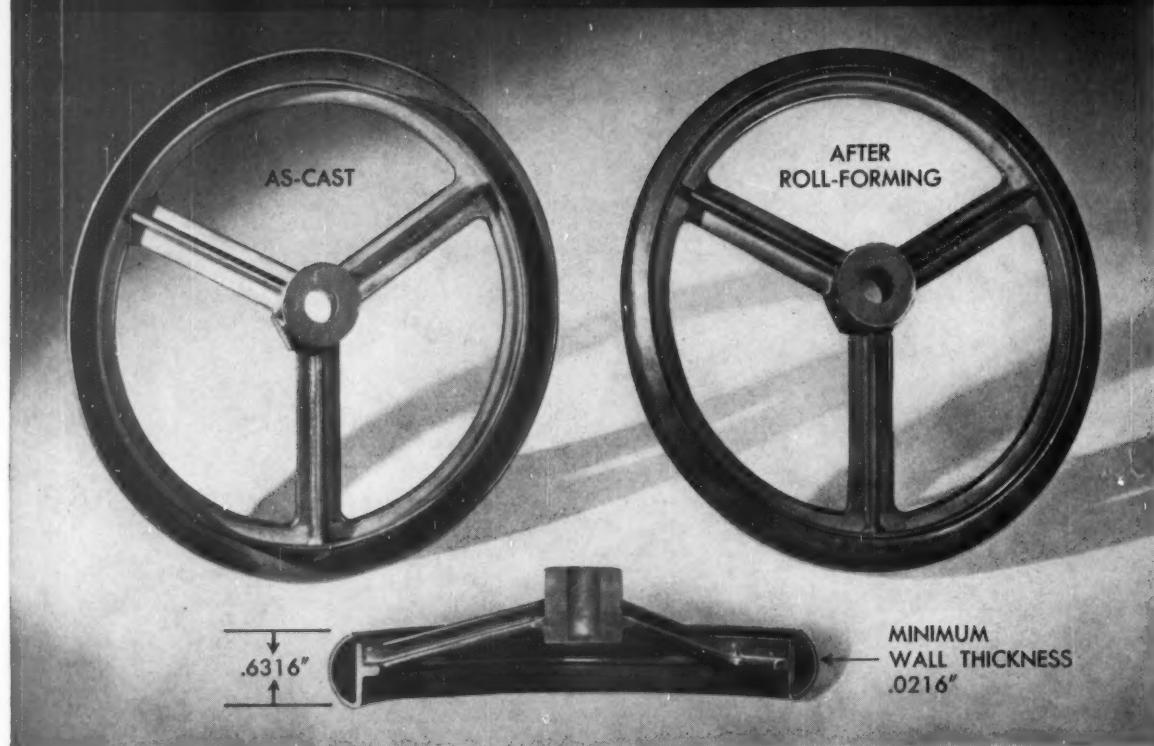
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March 17, 1960

**Guest Editorial**

## We Play It by Ear

HOW many times have you heard an engineer make that statement? Some engineers say it proudly, not seeming to realize that the very phrase itself is usually an admission of ignorance. Sometimes "playing it by ear" is necessary—for example, when extrapolation must be used because available information is not adequate.

Too often, however, the blacksmith approach is utilized out of indolence or ignorance, not because of necessity. Frequently an engineer blunders through, trying this method and that, experimenting haphazardly and needlessly, to find a result that he could calculate or look up in the literature. True, literature surveys and theoretical analyses are seldom as much fun as building new designs and testing them. Nor do these intellectual methods command the same respect from a near-sighted management.

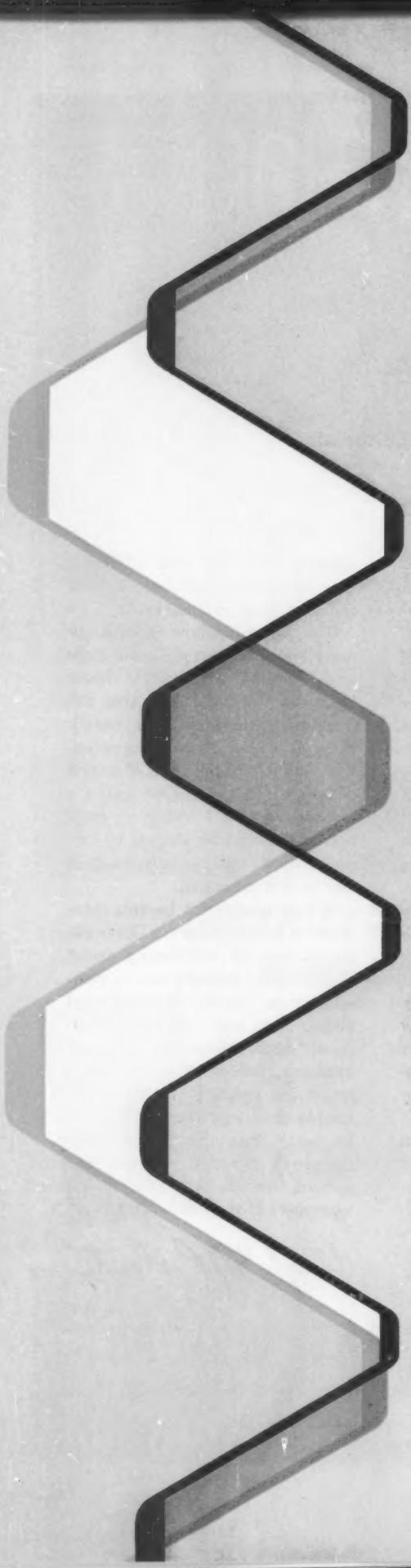
On the other hand, the analytical approach takes less time and is far less expensive when applied intelligently. But it often requires considerable mental effort and may be a real intellectual struggle. Reference to books and requests for information from experienced engineers may seem to be an admission of ig-

norance, and any such admission must be avoided at all costs—in both company time and money.

It is surprising how many engineers and administrators lose sight of the fact that utilization of theory is one of the big factors that differentiates engineers from technicians. A degree alone is meaningless. Ability to apply the education which led to the degree makes a man an engineer. When an engineer boasts that he plays it by ear, he is usually, unknowingly, boasting that he is a technician.

If they ignore this hazard, management and engineers can promote degradation of engineering talent and produce a concentration of semi-competents. Together, unenlightened management and "engineer-technicians" de-emphasize the analytical approach, fail to make intelligent use of the technical literature, and fumble their way along, playing it by ear. Thus, they restrict their company's growth and, more important, throttle the technical advancement of the nation.

LLOYD M. POLENTZ, P. E.  
WHITTIER, CALIF.



## *A fresh look at a basic question:*

**W. G. WALTERMIRE**

Chief Product Engineer  
The Lamson and Sessions Co.  
Cleveland, Ohio

**C**Hoice between coarse or fine screw threads requires a compromise—a balancing of the advantages and disadvantages of each thread series for the specific application. In many companies, there is a growing desire to standardize on one series. The advantages are clear: Simplification of stocks; reduction of fastener and threaded parts inventories; and elimination of duplicate stocks of manufacturing tools, drills, taps, and gages.

If an organization can standardize on one thread for a given size it will have obtained most of these objectives. However, individual analysis of each part, its functions in a joint, and its effect on assembly costs are required for such decisions. In some applications, assembly cost may be more important than strength. In other applications, the reverse will be true.

**Design Criteria:** There is no clear-cut yardstick to use in evaluating "strength." Unfortunately, strength is most often considered in terms of stress. However, the criterion in joint design is not stress, but the clamping load induced at assembly and the direct tension load required to fail the threaded part. On this basis, the fine-thread series is the "stronger" with normal materials.

In direct-tension type loading, clamping load protects against failure of the fastener. Almen<sup>1</sup> showed that  $\frac{3}{8}$ -24 connecting rod bolts, subjected to a cyclic operating load of 0 to 9215 lb failed in fatigue at 214,500 cycles when tightened to 7220 lb initially. They did not fail at 5,000,000 cycles when initially tightened to 8420 lb. Thus, a 17 per cent increase in clamping load produced a fatigue strength more than 23 times greater. This gain in fatigue strength

<sup>1</sup>References are tabulated at end of article.

# Coarse or Fine Threads?

Here are the results of a recent investigation to find some clear-cut answers to this long unsettled fastener problem.

is particularly important where nonrigid joint materials are bolted, or where gaskets, shims, or other compressible materials are included in the joint. In these types of joints, Fig. 1, a part of the service load is added to the tension load induced in tightening.

In shear type loading, the fatigue strength of the joint is often a critical requirement. Hansen<sup>2</sup> states, "The most important variable governing the fatigue strength of a joint is clamping force."

High clamping force, produced by tightening the fastener, is required to perform another prime function of a joint—resisting slip under static or fatigue loading. Slippage is particularly likely when materials of low coefficient of friction are bolted together, since it is prevented only by clamping force acting through friction of the connected members. Fig. 2 shows the nature of this slip in 4-bolt, flat plate, splice type joints, using regular ASTM A-325 bolts.<sup>3</sup> The Joint Research Council on Bolted and Riveted Joints found it necessary to adopt bolt clamping loads near the proof load values (90 per cent of yield strength) to produce best antislip characteristics and highest joint fatigue strength.

**Ultimate Strength:** An investigation was conducted to determine the strength characteristics of coarse and fine threads, eliminating as many variables as possible. A production lot of C-1038 bolts was cold headed to the  $\frac{1}{2}$ -20 blank size. Half of them were then reduced to the  $\frac{1}{2}$ -13 blank size. Both series were roll threaded to produce about the same percentage of thread depth and were then heat treated to the same hardness. The bolts were assembled in hardened adapters and pulled to failure. Results are shown in Table I.

Actually, the ratio of mean stress areas, fine to

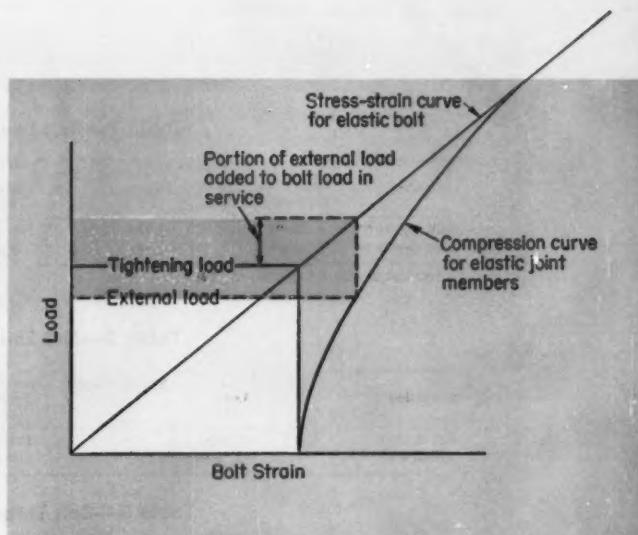


Fig. 1—Effect of elasticity of bolted members.

coarse, gives a theoretical 12.7 per cent advantage to the  $\frac{1}{2}$  in. size. The greater necking down of SAE Grade 2 bolts may be responsible for their developing less load advantage in the tests.

The stresses reported in Table I are within normal limits of lot variation.

In practice, a fastener is torqued to produce the desired pretensioning, or *clamping load*. In a tension application, failure of such a part will be in direct tension due to addition of *external load*. Obviously, the fine thread shows a superiority here.

Nuts are a different matter. *The function of a nut*



COARSE OR FINE THREADS?

is to withstand the minimum rated breaking load of a bolt without failure. Above this strength level, it does not matter which series produces the highest nut stripping strength.

To investigate nut performance, a production lot of  $\frac{1}{2}$ -13 heavy-hex nut blanks was cold forged. Half of them were reamed to a size within the  $\frac{1}{2}$ -20 minor diameter limits to produce an equal percentage of thread depth. Both series were then tapped to about the same fit on their respective GO (LO) thread plug gages. Nut hardness was Rockwell B 93-91 for both series. Some of the nuts in each series

were annealed to Rockwell B 45-47 to simulate low-strength tapped-hole materials. Nuts were then tested in direct tension for strip loads on hardened mandrels. Results are summarized in Table 2.

Note that the stripping strength, both loads and stresses, of these relatively soft "as forged" nuts exceed the breaking loads reported in Table 1 for the harder bolts. Also, the nut strip loads are about the same for both series. But in contrast to the bolt tests, the stripping stresses are different. It is the loads which are of interest.

Both thread series in the "as forged" condition develop nut stripping loads and stresses higher than the bolt breaking strength. Therefore, there is no advantage for either series.

The "as forged" nuts were then torqued to destruction on SAE Grade 2 and on Grade 5 bolts. All bolts necked and broke. Results are shown in Table 3 and in Fig. 3 and 4.

#### Torque-Tension Relationships: Strength superiority

Table 1—Bolt Load and Ultimate Stress

Grade	Hardness (Rockwell C)	1/2-13 Thread		1/2-20 Thread		Load advantage of fine thread (per cent)
		Load (lb)	Stress (psi)	Load (lb)	Stress (psi)	
SAE Grade 5*	28-29	18,400	130,000	21,000	131,500	14.1
SAE Grade 2†	94-95.5	13,340	94,200	14,600	92,400	9.5

\*ASTM A 325. †Approx. ASTM A 307.

Table 2—Nut Load and Ultimate Stress

Condition	1/2-13 Thread		1/2-20 Thread	
	Load (lb)	Stress (psi)	Load (lb)	Stress (psi)
As forged	27,600	194,600	25,700	167,200
Annealed	17,100	119,600	18,400	105,000

Table 3—Bolt Torque and Load at Failure

Grade	1/2-13 Thread		1/2-20 Thread		Torque advantage of fine thread (per cent)	Load advantage of fine thread (per cent)
	Torque (lb-ft)	Load (lb)	Torque (lb-ft)	Load (lb)		
SAE Grade 5	130	15,450	150	18,120	14.5	17.2
SAE Grade 2	95	11,050	100	12,600	5.2	13.9

Table 4—Load-Torque Relationships at Constant Assembly Torque

Grade	1/2-13 Thread		1/2-20 Thread		Load advantage of fine thread (per cent)
	Torque (lb-ft)	Load (lb)	Torque (lb-ft)	Load (lb)	
SAE Grade 5	90	10,510	90	11,200	6.6
SAE Grade 2	60	7,060	60	7,790	10.2

Table 5—Load-Torque Relationships at Varying Assembly Torques

Grade	1/2-13 Thread		1/2-20 Thread		Load advantage of fine thread (per cent)
	Torque (lb-ft)	Load (lb)	Torque (lb-ft)	Load (lb)	
SAE Grade 5	75	8,600	90	11,200	30.3
SAE Grade 2	50	5,800	65	7,150	21.8

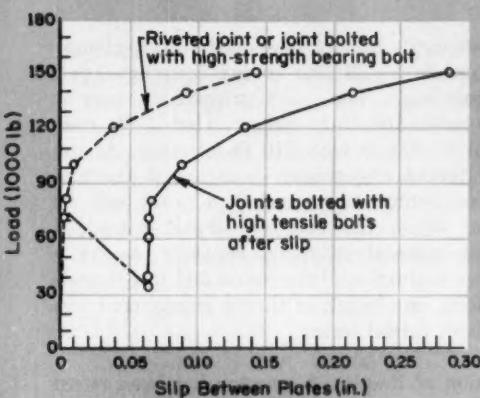


Fig. 2—Typical load-slip relationships in bolted joints.

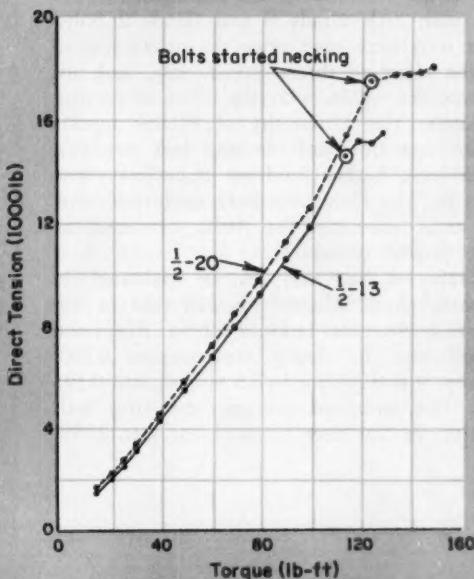


Fig. 3—Torque-tension relationships for SAE Grade 5 hex-head cap screws with "as forged" heavy-hex nuts, loaded to failure.

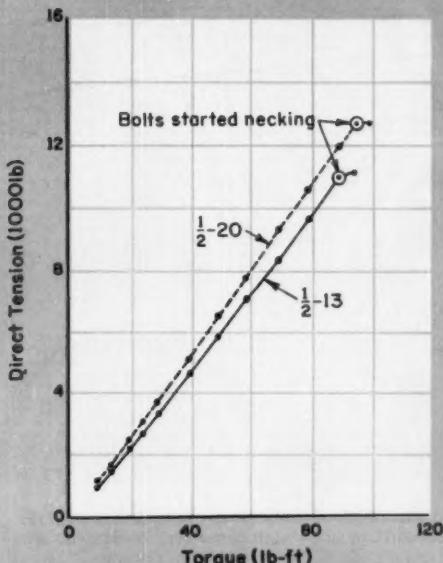


Fig. 4—Torque-tension relationships for SAE Grade 2 hex-head cap screws with "as forged" heavy-hex nuts, loaded to failure.

of the fine thread bolt-and-nut assembly is to be expected. However, the fact is often overlooked that fine threads, under these conditions of assembly, will take higher torque loads before failing. Torque failure in assembly may occasionally occur because of variable wrenching conditions; lubrication; platings and coatings; out-of-square assembly conditions which impose eccentric loads; and variations in material strength and thread workmanship. Since the fine-thread bolt has a larger thread-root diameter, it also has higher torsional strength as well as higher shear strength. The latter value is readily calculated from standard formulas for thread shear area.<sup>4</sup>

Since bolts and nuts are not designed to be torqued to failure, loads developed at actual assembly torques are of primary interest. For a given assembly torque, the results are as tabulated in Table 4. These results show that for a given clamping load, less torque is needed by the fine thread.

Ability of a fine thread bolt to withstand higher torque loads is well established. Most users set assembly torques higher for fine threaded products than for coarse threads. A large automotive manufacturer assembles to loads equal to  $\frac{3}{4}$  the proof load. Using their recommended torques, the foregoing bolt and nut assemblies (Table 4) were tested and developed the advantage for the fine thread shown in Table 5.

These results clearly show the strength superiority of fine threads over coarse threads, so long as the nut is made of common steel or higher strength material. The higher assembly loads obtained also

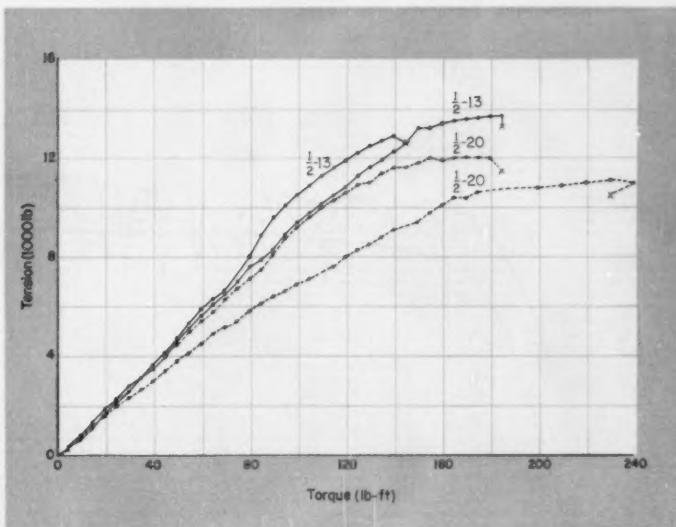


Fig. 5—Torque-tension relationships for SAE Grade 5 cap screws with "annealed" heavy-hex nuts. Loads were applied by torquing nut. All nuts stripped.

provide more elastic bolt strain, which gives greater protection against fatigue failure. They develop higher clamping force, thus better performing another major function: Prevention of slippage.

The question then arises: For a given strength requirement, couldn't fastener size and costs often be reduced by simply using a fine thread? Why not, when the smaller fine-thread fastener can be safely loaded much higher than its coarse-thread counterpart?

Fig. 5 shows that coarse threads proved best in tests with annealed nuts on SAE Grade 5 bolts. At

90 lb-ft torque,  $\frac{1}{2}$ -13 bolts developed 8950 lb clamping load, while  $\frac{1}{2}$ -20 fine thread nuts developed 7250 lb bolt loads. The  $\frac{1}{2}$ -13 stripped the nuts at 12,950 lb with 165 lb-ft torque. The  $\frac{1}{2}$ -20 nuts stripped at 11,000 lb with 210 lb-ft torque. As the length of thread engagement is increased (normal practice for nonferrous material) a point will be reached at which the bolt will break instead of the tapped material stripping. However, to get a comparative evaluation of the coarse and fine threads in these tests, one length of thread engagement was used for both thread series.

**Evaluation of Results:** A question has been raised as to how these results can be reconciled with the results of tests currently being conducted at Case Institute of Technology. There is no conflict. These tests were made with heavy-hex semifinished nuts assembled with SAE Grade 5 and Grade 2 bolts. Heavy-hex nuts were used since the object was to compare the effect of thread series only, and not to complicate the results with the effect of varying wall thickness. The University of Illinois reports that finished-hex nuts will develop bolt strength, but should have higher hardness than heavy-hex nuts to do so. The Case tests were made with finished-hex nuts assembled on bolts hardened as mandrels to provide reusability.

Results reported here can also be evaluated on another basis. G. A. Maney<sup>6</sup> showed that in the simplified torque-tension formula  $PL = RDT$ , the torque coefficient,  $R$ , closely approximates 0.200. Theoretically, it is 0.201 for  $\frac{1}{2}$ -13 threads and 0.195 for  $\frac{1}{2}$ -20. The measured average, including both thread series, in the sizes  $\frac{1}{4}$  to 1 in. was 0.198,

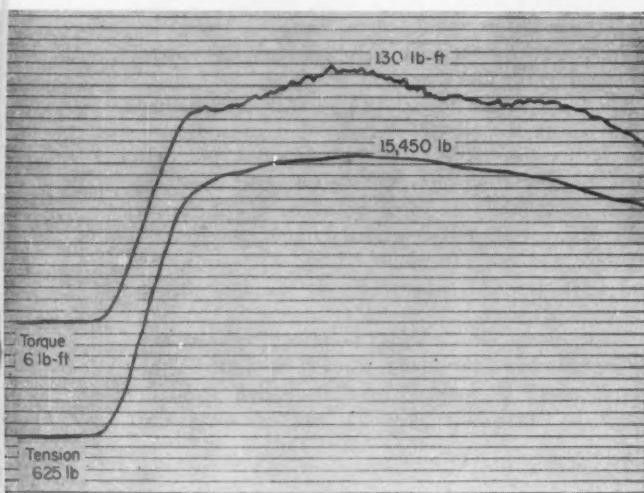


Fig. 6—Autographic recording of manual torque-to-destruction test of  $\frac{1}{2}$ -13 Grade 5 hex-head cap screw with heavy-hex, "as-forged" nuts.

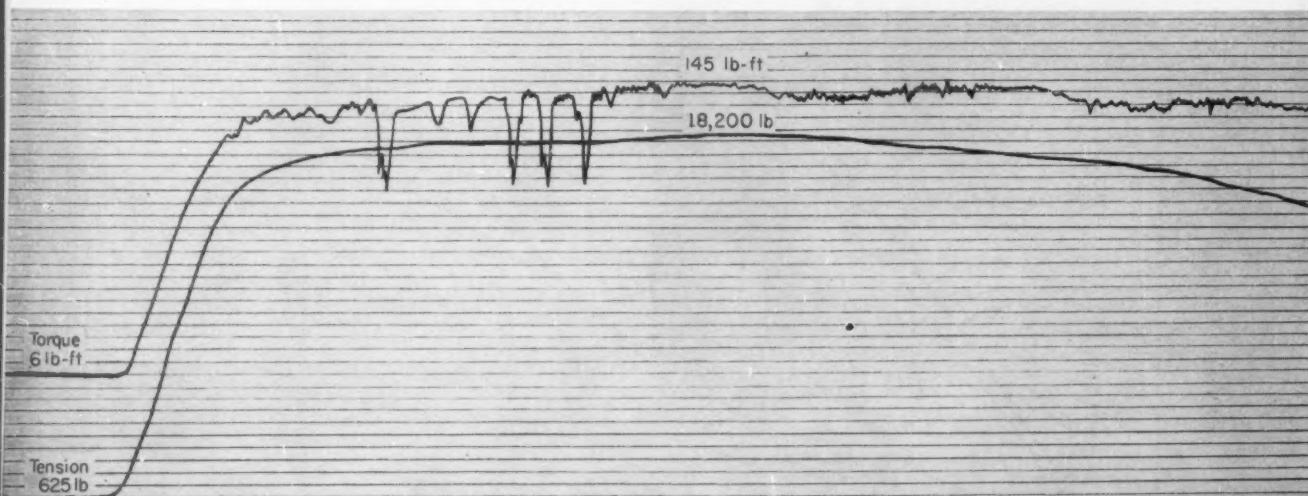


Fig. 7—Autographic recording of manual torque-to-destruction test of  $\frac{1}{2}$ -20 Grade 5 hex-head cap screw with heavy-hex, "as-forged" nuts

with the coefficient for the fine thread generally being 0.005 less than for the coarse thread.

The Case Institute tests developed torque coefficients of 0.208 to 0.293. These results are to be expected since these particular tests were conducted to determine nut strip torques on hardened mandrels. When nuts strip, the torque tends to go up as the bolt load starts to go down.

Torque coefficients of the tests reported in this article are:

Table 3:

SAE Grade 5:  $\frac{1}{2}$ -13,  $R = 0.204$ ;  $\frac{1}{2}$ -20,  $R = 0.199$   
SAE Grade 2:  $\frac{1}{2}$ -13,  $R = 0.212$ ;  $\frac{1}{2}$ -20,  $R = 0.191$

Table 4:

SAE Grade 5:  $\frac{1}{2}$ -13,  $R = 0.210$ ;  $\frac{1}{2}$ -20,  $R = 0.194$   
SAE Grade 2:  $\frac{1}{2}$ -13,  $R = 0.208$ ;  $\frac{1}{2}$ -20,  $R = 0.185$

Table 5:

SAE Grade 5:  $\frac{1}{2}$ -13,  $R = 0.208$ ;  $\frac{1}{2}$ -20,  $R = 0.196$   
SAE Grade 2:  $\frac{1}{2}$ -13,  $R = 0.205$ ;  $\frac{1}{2}$ -20,  $R = 0.185$

These data are evidence of the validity of the combinations of torque and tension values reported here, from which these torque coefficients are developed.

Another simple check can be made by comparing the induced bolt tensions at failure under torque (Table 3) with the bolt tension loads in direct tension (Table 2). The ratios are 0.84 and 0.83

COARSE OR FINE THREADS?

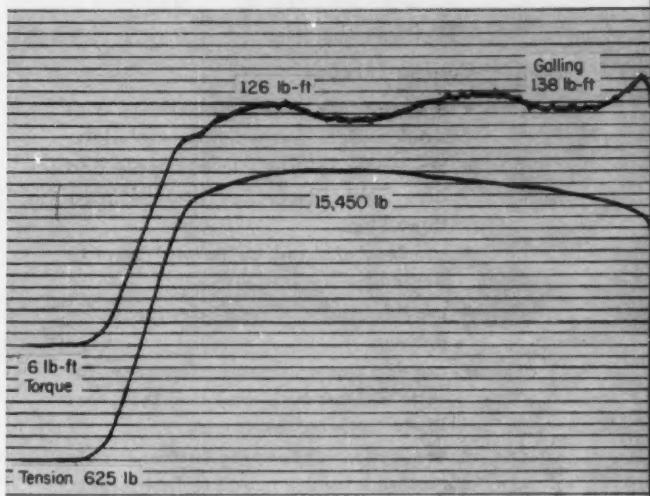


Fig. 8—Autographic recording of manual torque-to-destruction test of  $\frac{1}{2}$ -13 Grade 5 hex-head cap screws with finished hex nuts

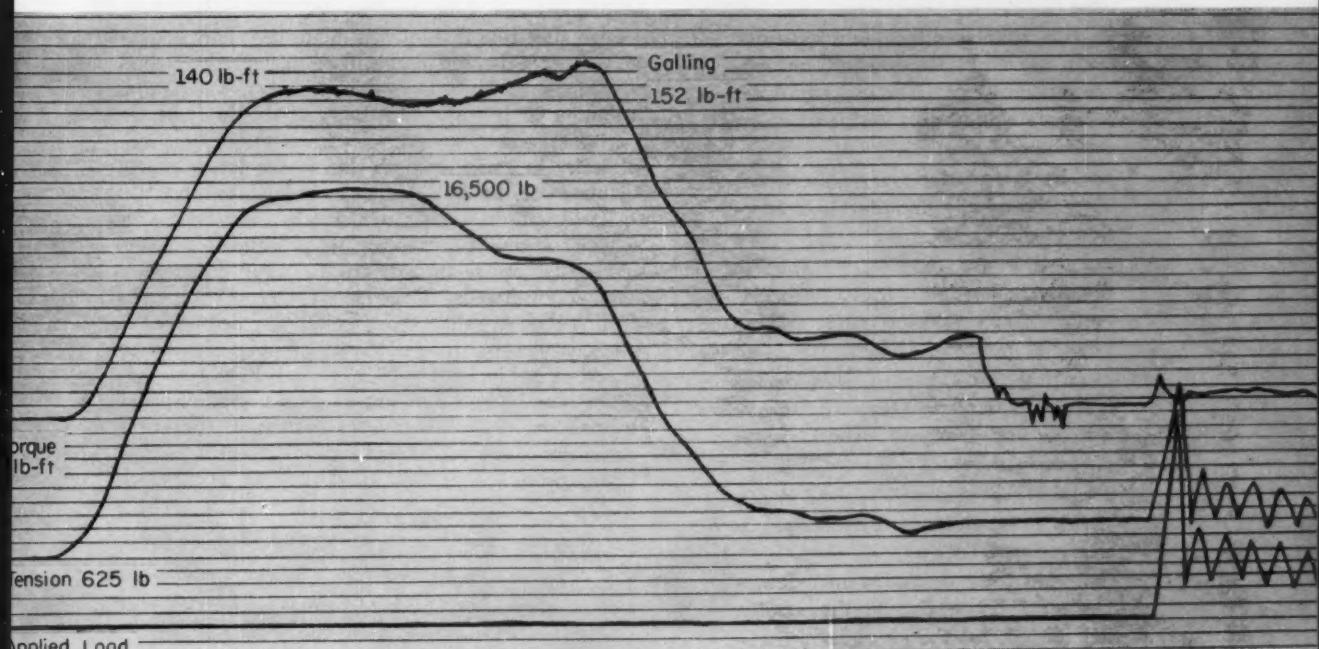


Fig. 9—Autographic recording of manual torque-to-destruction test of  $\frac{1}{2}$ -20 Grade 5 hex-head cap screws with finished hex nuts.



COARSE OR FINE THREADS?

## Thread Comparison

### Coarse threads

- are stronger when assembled with weak nut or tapped-hole materials.
- are easier to locate in assembly and give better protection against cross threading.
- are less affected by normal burrs in assembly.
- provide more thread clearance for plating.
- provide more thread clearance for corrosion products and are, thus, less likely to seize in service.
- are better for tapping brittle, friable materials which crumble in tapping.
- are stronger for large sizes, over 1 in.

### Fine threads

- are stronger with tapped-hole materials normally used in design and greatly increase clamping force on joint.
- provide greater adjustment accuracy such as might be needed on set-screws and cam followers, and for lining up slotted nuts with cotter pins and drilled holes.
- can be threaded closer to the head, since thread die chamfer is a function of pitch.
- are better for tapping or chasing threads in hard materials since advance per revolution and volume of metal removed is less.
- are best for tapping thin-walled members because tapping torque is lower and stronger for short lengths of engagement.
- are stronger for sizes 1 in. and under, gaining in strength advantage as size reduces.
- maintain joint tightness and clamping force better due to the smaller helix angle of the thread.

for the  $\frac{1}{2}$ -13 Grade 5 and Grade 2 tests and 0.86 for the  $\frac{1}{2}$ -20 tests for both grades. These ratios are accepted values.

Finally, Fig. 6 and 7 are autographic recordings of hand torque-to-destruction tests duplicating the original stop-read-record and start tests plotted in Fig. 3 and 4. Time (chart speed) is plotted horizontally. The upper curve is applied torque, the bottom curve is induced tension. As these plots show, the fine threaded assembly developed higher torque and higher tension loads. Note also that a greater length of time was required to fail the fine thread. The times actually required to load to assembly torque are almost identical for both series. This result disproves the claims that coarse threads "drive faster."

Fig. 8 and 9 repeat the torque-to-destruction tests of Fig. 6 and 7 except that finished-hex nuts, instead of heavy-hex nuts, were used. If Fig. 8 is compared with Fig. 6, it is interesting to note that the ultimate tensile strengths induced in the bolts were the same. This result is to be expected, since the bolts were of the same lot. Further, in Fig. 8, as the bolt starts yielding and the induced tension load falls off, the torque does not drop as it did with the heavy-hex nut in Fig. 6. Dilation of the thinner walled finished-hex nut is the apparent explanation. The same development is noted with the  $\frac{1}{2}$ -20 fine-threaded finished-hex nut in Fig. 9. Here, the bolt did not break, but the nut stripped at an induced tension load about 1050 lb above the breaking load of the  $\frac{1}{2}$ -13 bolt shown in Fig. 8. The tensile strip load at failure with the finished-hex nut test of Fig. 9 is 1700 lb less than the bolt breaking load found with the  $\frac{1}{2}$ -20 heavy-hex nut in Fig. 7.

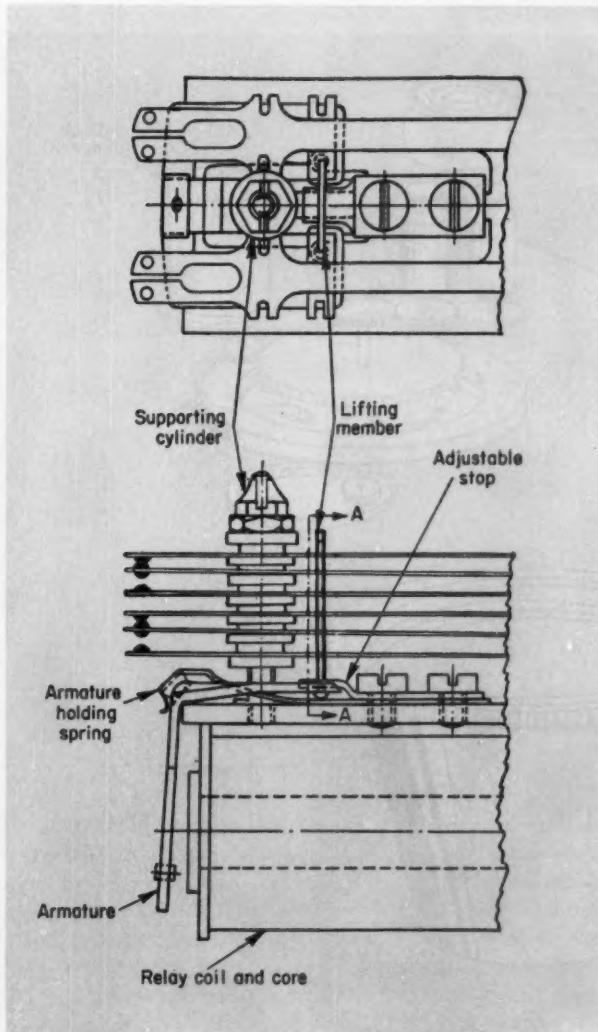
The tests at Case Institute of Technology have shown that fine-thread nuts dilate less than coarse-thread nuts. Reason argues that fine-threaded bolts would contract less. Does this mean better stress distribution in fine threads? If so, it should result in superior fatigue strength as well as the obvious superiority in static strength due to the larger minor diameter of the fine-threaded external member.

Based on these tests, which are consistent with experience and observations, it is difficult to conclude that coarse threads are as strong or stronger than fine threads. The opposite seems true. But further data are still needed before any definite conclusions can be drawn. Many variables should be investigated including: Power and hand driving; differences in bolt and nut materials; platings; and lubrication. A comparative evaluation of the characteristics of the two thread series is given in *Thread Comparison*.

### REFERENCES

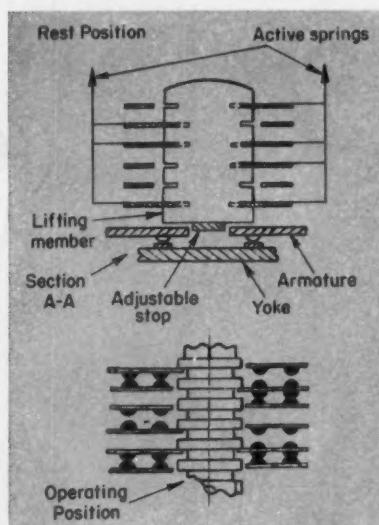
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2. N. G. Hansen—"Fatigue Tests of Joints of High Strength Steel," *Proceedings of ASCE*, Vol. 85, No. ST3, March, 1959.
3. W. H. Munse—"An Evaluation of the Behavior of Structural Connections Assembled With Hook Knurl Bolts," published by W. H. Munse, University of Illinois, Urbana, Ill., Sept. 1957.
4. *Screw-Thread Standards for Federal Services*, National Bureau of Standards Handbook H28, U. S. Dept. of Commerce, 1957, p. 5.
5. G. A. Maney—"Predicting Bolt Tension," *Fasteners*, Industrial Fasteners Institute, Cleveland, Ohio, Vol. 3, No. 5.

# scanning the field for *ideas*



## Uniform contact pressure

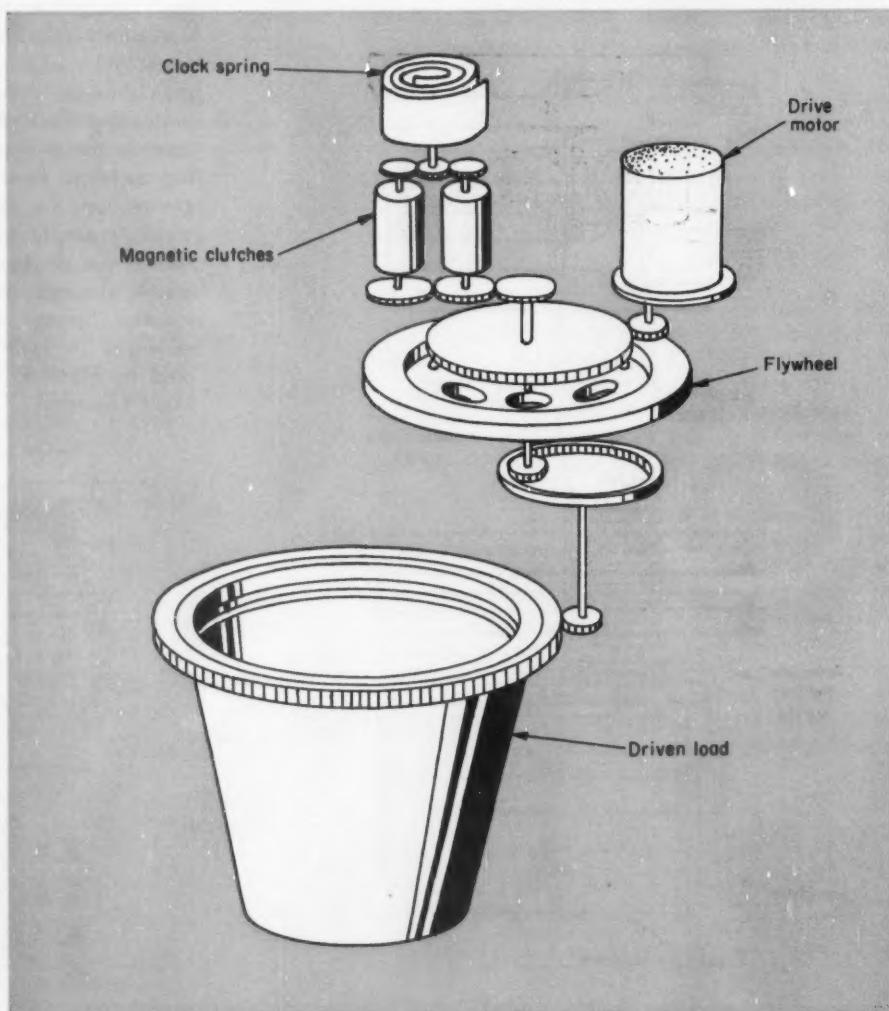
is provided by single lifting member that controls springs of knife-edge relay. Lifting member is actuated by armature which, held by spring, pivots about yoke edge. Active springs engage slots in lifting member through protruding flaps. An adjustable stop controls the zero position of the lifting member. Passive springs rest in grooves on the supporting cylinder, which is axially adjustable. As active springs are displaced, passive springs travel through width of cylinder grooves. Spring mounting principle employed in knife-edge relay developed by Mansfeld GmbH, Frankfurt/Main, Germany.

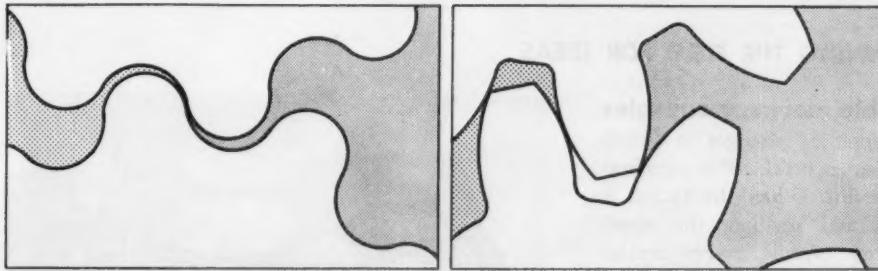


## SCANNING THE FIELD FOR IDEAS

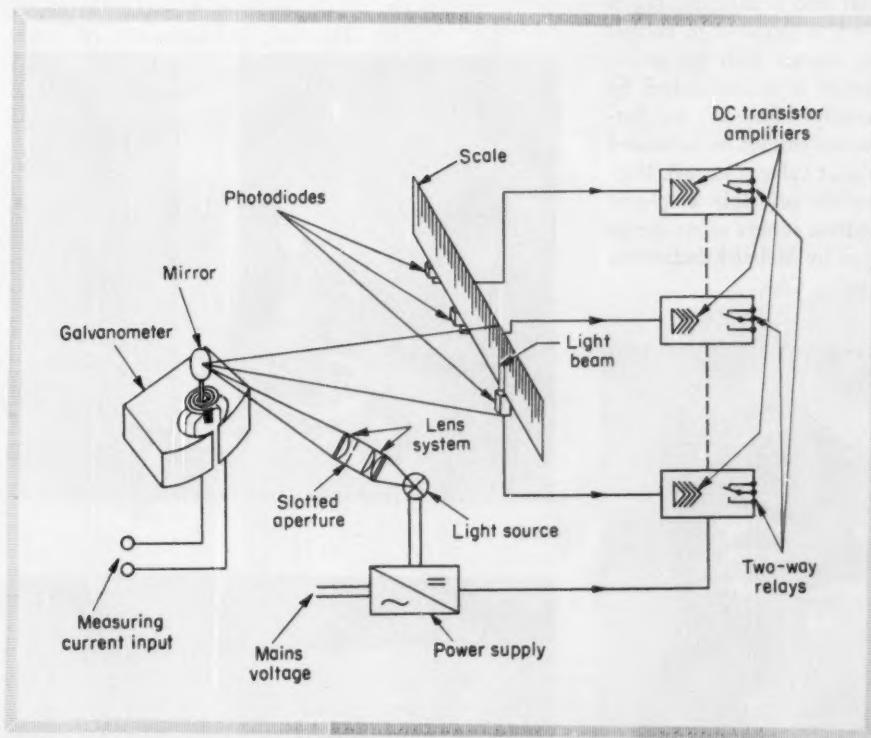
**Spring torque booster** permits low-torque motor to rapidly reverse high inertia loads in a scanning mechanism. To supplement the torque of the drive motor, the reduction gear train contains a reversing mechanism, consisting of two magnetic clutches connected to a clock spring. One end of each clutch is geared directly to a flywheel, and each clutch rotates at flywheel speed. At the instant the motor is reversed, one of the clutches is engaged and the kinetic energy of the flywheel is stored in the clock spring. The resultant "kick" provided by the spring in releasing this energy reverses the entire system. For the next reversal, the other clutch is engaged. This alternate operation, plus the gearing,

causes the clock spring to be wound in the same direction during each reversal. Torque-booster principle employed in high inertia scanning system developed by Walter T. Fandel Jr., engineer, Baird-Atomic Inc., Cambridge, Mass.





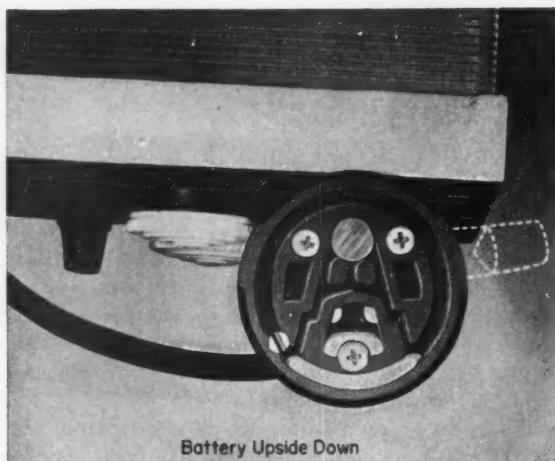
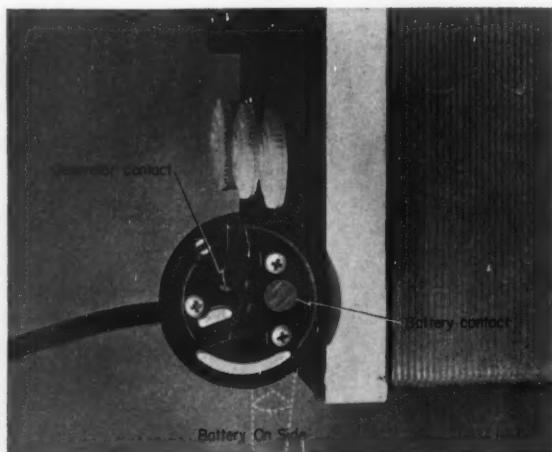
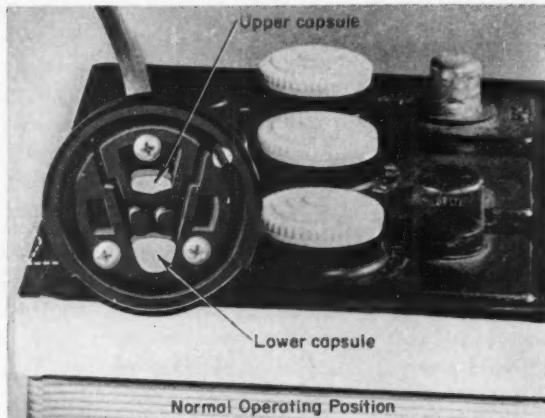
**Elliptical tooth profile** increases contact area to raise gear-pump efficiency. With this profile, the gears intermesh accurately to eliminate liquid trapping and corresponding efficiency losses. In conventional spur or helical gears, the "square" shaped teeth pick-up and trap liquid between them rather than squeezing it all out as they are meshed. Tooth profile employed in the Hydroid gear pump developed by Hupp Aviation Corp., Chicago.



**Electronic limit switches** are provided by photodiodes that are "triggered" by angular movements of a galvanometer-controlled light beam. Design uses a standard mirror galvanometer, which deflects light emitted by a stationary light source. The light is projected through a lens system and slotted aperture. Deflection is proportional to measuring current. As the light beam passes a photodiode, an amplifier actuates a two-way relay. Switching principle employed in automation controls manufactured by Telefunken GmbH, Backnang/Wuertt, Germany.

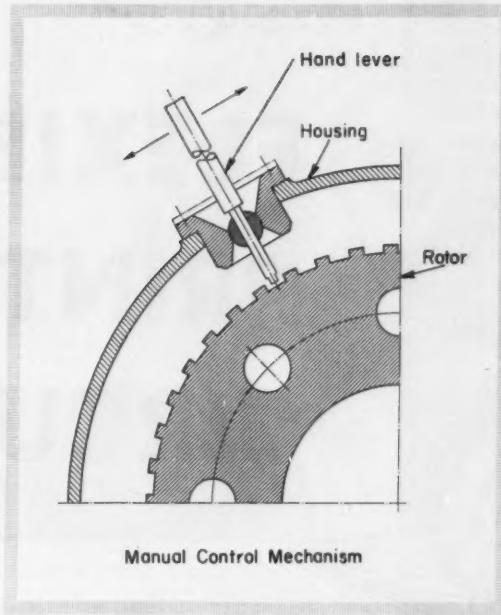
## SCANNING THE FIELD FOR IDEAS

**Double mercury capsules** are upset by changes in switch position to break battery-generator circuit. When the switch is in normal position, the upper mercury capsule makes contact with the generator and lower capsule with the battery. When the switch is tilted beyond a certain angle, contact with the generator is broken through mercury displacement in the upper chamber. Contact with the battery is broken at the same time when the mercury in the lower capsule flows out into a channel. When the switch is returned to normal position, contact with the generator circuit is re-established by the mercury. However, the battery contact cannot be reinstated until a reset valve is turned. Mercury switch principle employed in Fyre-Blok vehicle safety device developed by Melnick Industries, Chesapeake, Ohio.

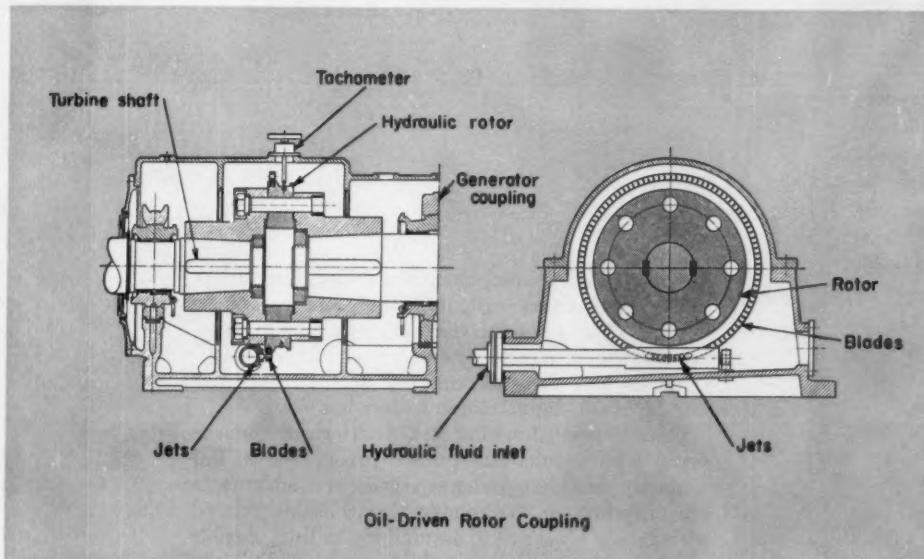


### **Oil-driven rotor coupling**

turns steam turbine after steam is shut off to insure uniform heat distribution in shaft and runner. In a turbine-generator system, a secondary rotor is located between turbine and generator. Hydraulic fluid, ejected against the rotor blades through jets, is supplied by the turbine's auxiliary oil pump to drive the turbine shaft. To permit manual setting of turbine runner and shaft for adjustment, a hand lever engages with teeth which are cut in the oil rotor. Auxiliary rotor-drive principle employed in steam turbines developed by Siemens-Schuckertwerke AG, Muelheim/Rhur, Germany.



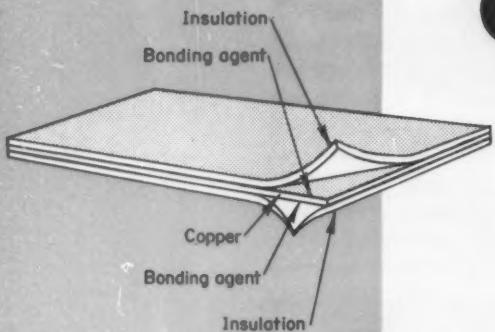
Manual Control Mechanism



Oil-Driven Rotor Coupling

*How to design electric  
and electronic packages  
using . . .*

Custom-etched, flexible printed wiring is designed to fit the configuration and dimensions required for a particular electric or electronic circuit. The etched circuit is composed of copper conductors encapsulated in any of a wide variety of flat, flexible, insulating plastics.



Bond between conductors and insulation is virtually indestructible. Insulation cannot be peeled off—without first destroying the unit. Thus, the bond provides an effective barrier against penetration of moisture or gases.

# FLEXIBLE PRINTED CIRCUITS

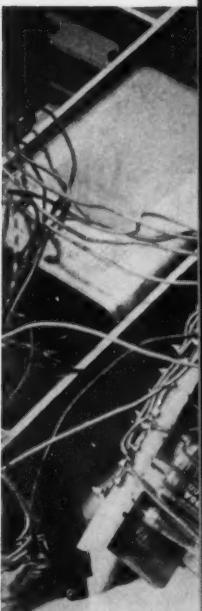
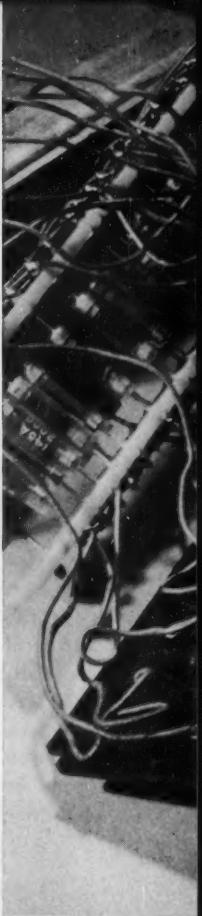
**VICTOR DAHLGREN**

Manager, Product Engineering  
Flexprint Products Div.  
Sanders Associates Inc.  
Nashua, N. H.

**F**LEXIBLE printed circuits are flat, thin cables and harnesses custom-tailored and mass-produced for a specific electronic or electrical package. They offer one prime advantage: Efficient packaging into a three-dimensional arrangement that can be small, light, efficient, and less costly.

Flexible printed wiring is a marriage of conventional wire circuits and printed-circuit boards. But distinctly new design characteristics and advantages are offsprings of the combination. Flexible printed wiring uses a variety of insulations in thin, flexible plastic, with only the terminations exposed. Truly a printed circuit, the flat conductors can take any configuration (to close tolerances) required by the circuit layout. The circuit can be bent, twisted, coiled, preformed, and fitted flat into corners. Feeder arms can take off from the main cable in any direction.

This close conformation to package geometry re-



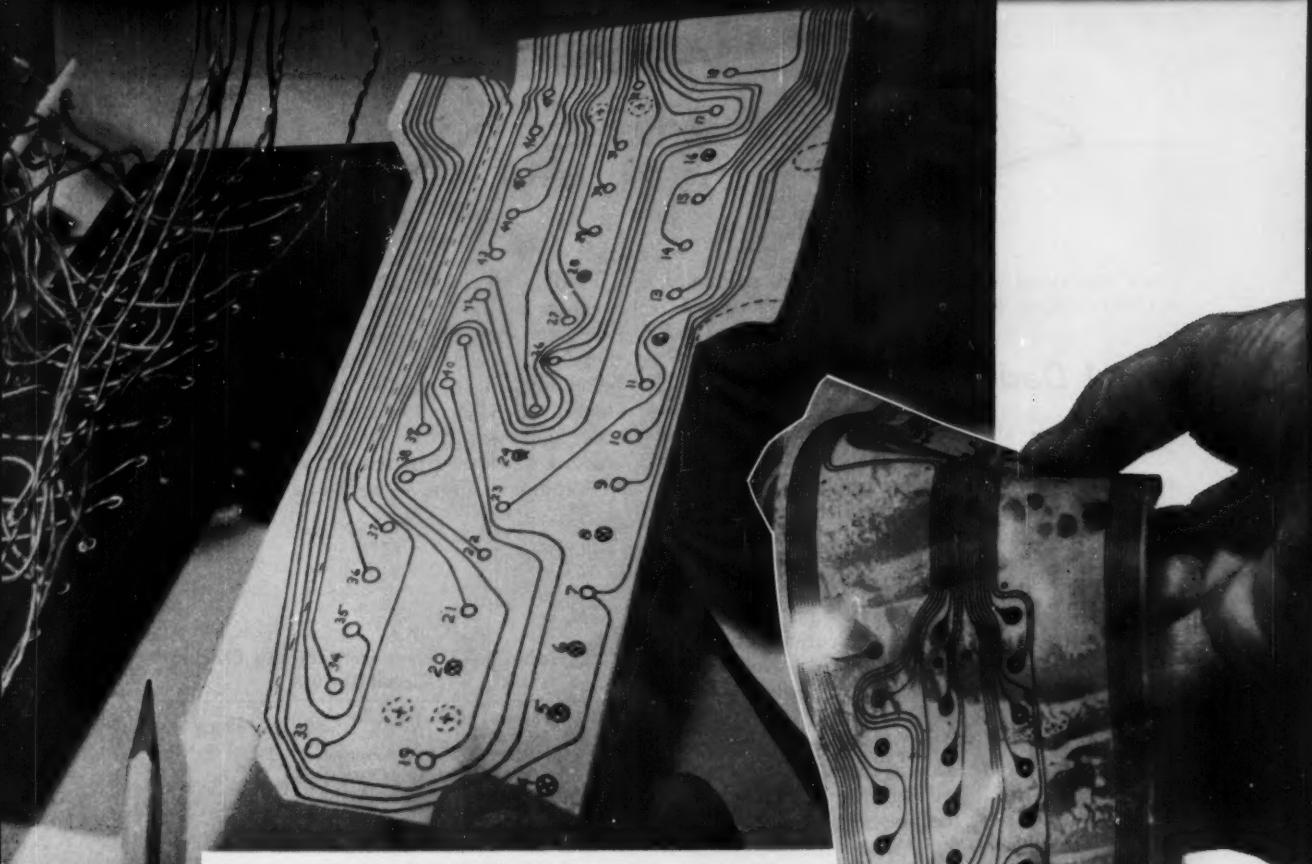
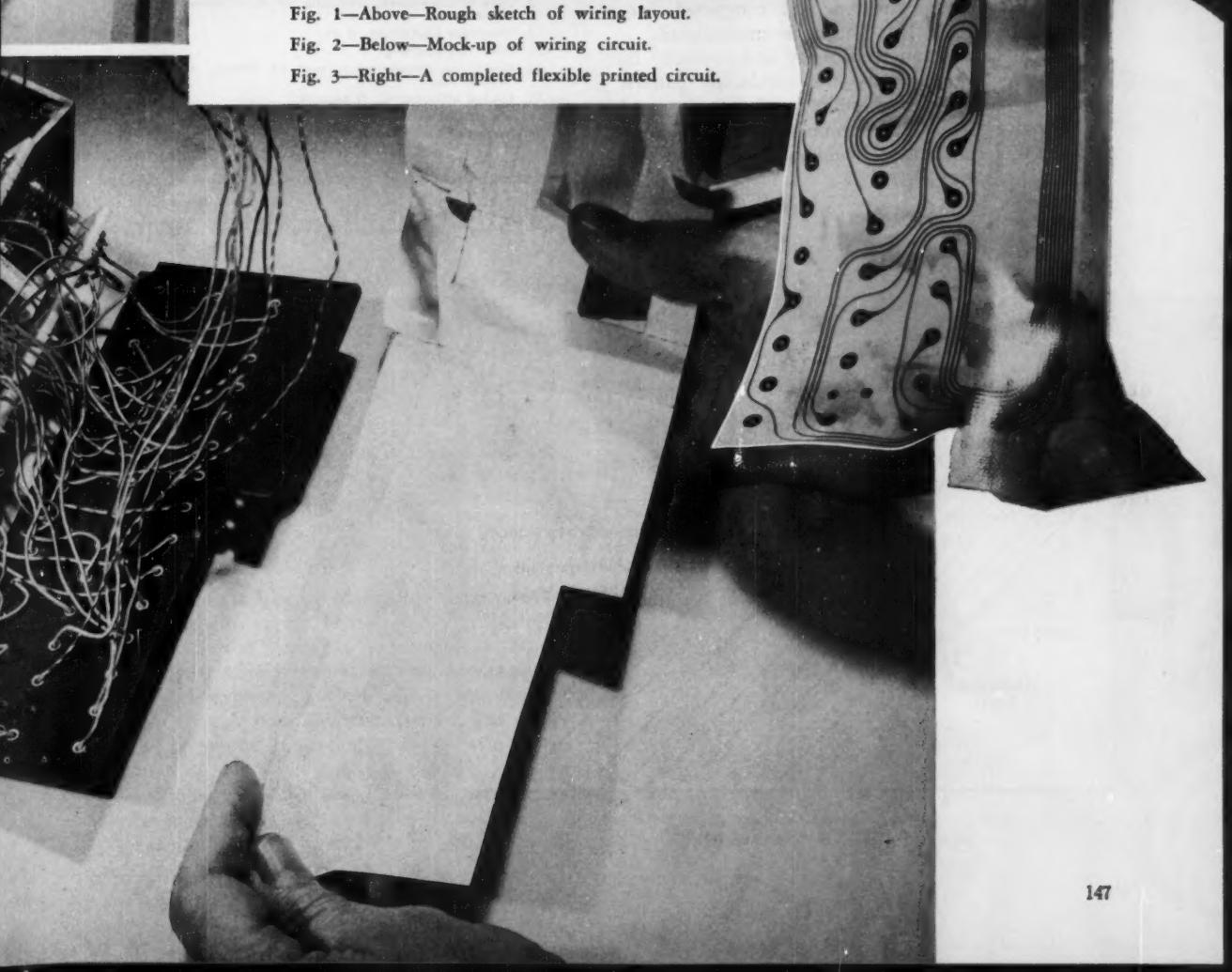
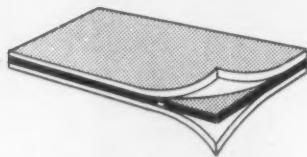


Fig. 1—Above—Rough sketch of wiring layout.

Fig. 2—Below—Mock-up of wiring circuit.

Fig. 3—Right—A completed flexible printed circuit.





FLEXIBLE PRINTED CIRCUITS

duces space and weight. And wiring is positioned automatically, so assembly is virtually "idiot-proof."

## Initial Design Steps

Projected use of flexible printed wiring does not affect any design considerations until the early model, or prototype stage is reached. Then, such factors as package form, size, weight, construction, cost, and environment pose a myriad of problems that can be solved with this new circuitry.

To design the flexible printed circuit, a rough sketch of the wiring layout is the first step, Fig. 1. When perfected to the point of accurate positioning and detailed dimensions, this sketch evolves into master artwork for reproduction. During the in-between stages, the sketch is refined to a mock-up of the wiring circuit. It can be made of cardboard, paper, or transparent acetate, Fig. 2. A transparent mock-up is especially useful for planning multi-layer circuits. The paper mock-up can be folded, cut out, formed to fit corners, and cut to conform to components—exactly the way the completed flexible printed circuit, Fig. 3, can be manipulated.

To achieve maximum efficiency and economy in printed-circuit production, the conductor pattern should be arranged, if possible, to obviate the need for crossovers. Also, all terminations (uninsulated portions) of conductors should appear on one side only.

Flexible printed circuits manufactured with crossovers as multilayers and with terminations on both sides are more complicated to manufacture and, therefore, more costly. At this early stage they should be eliminated, if possible. Under certain circumstances, the dictates of high circuit density, small size, light weight, or simplified assembly require crossovers. These requirements can all be met.

Continually, it must be borne in mind that the

Table 1—Factors Determining Efficient Circuit Design

1. Shape of cable, circuit, or harness.
2. Dimensions.
3. Number of layers of conductors.
4. Circuit arrangement of each layer.
5. Current capacity of conductors.
6. Operating voltages.
7. Operating temperatures.
8. Other environmental conditions.
9. Type of connectors, terminals, or other means of attachment.
10. Thickness limitations, if any.
11. Need for shielding.
12. Mechanical requirements, such as flexing, abrasion, tearing, etc.
13. Method of mounting, if required.
14. Identification of areas which may need stiffening.
15. Preferred materials.

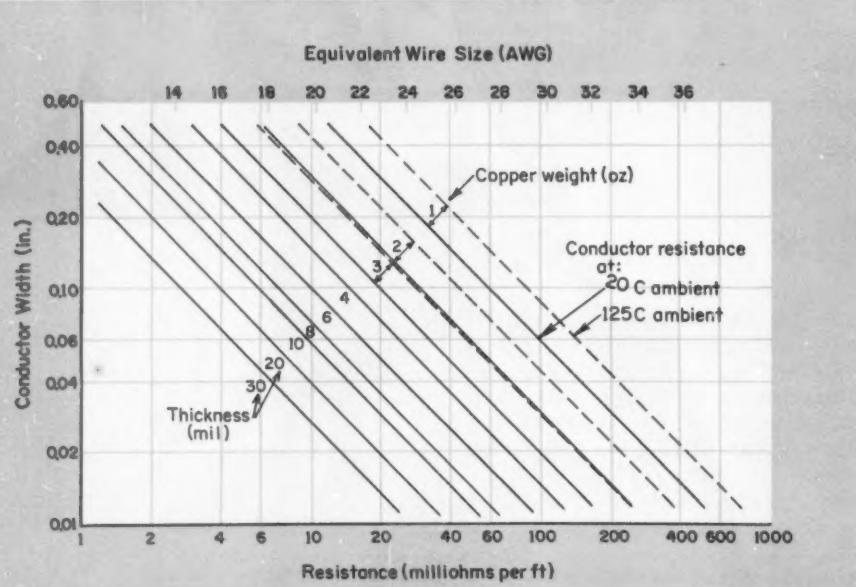


Fig. 4—Resistance and equivalent wire size for various weights and widths of copper.

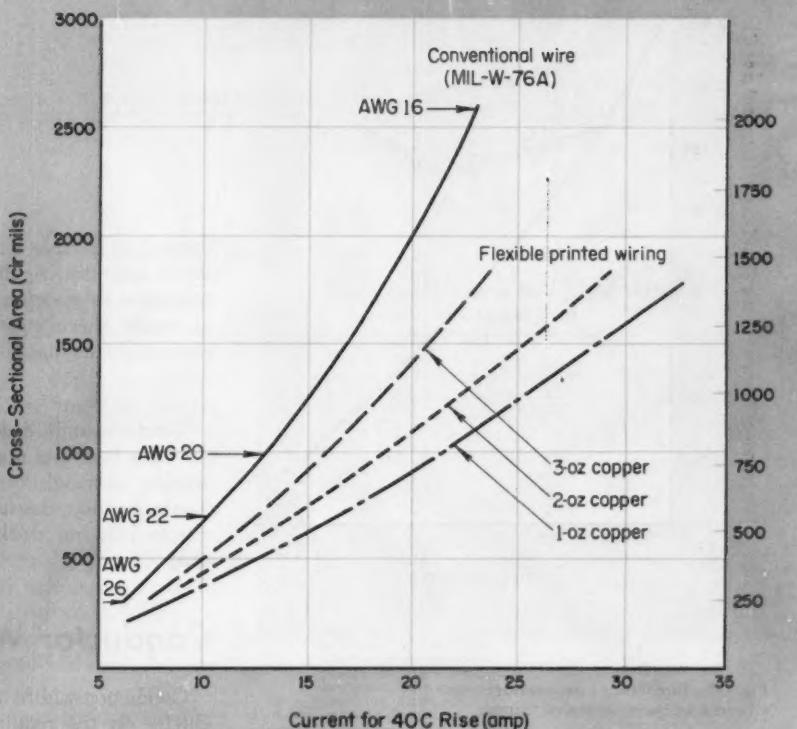


Fig. 5—Current-carrying capacity of flexible printed wiring compared with standard wire. Flat, flexible wiring has inherent conductor characteristics superior to conventional wiring with equivalent cross-sectional area.

surface of a flexible printed circuit is not confined to a single plane. It may be in many planes, perpendicular or stacked.

## Specifications and Materials

By use of common printed-circuit techniques, the design-drafting group can prepare final artwork and, often, photographic negatives for reproduction. When the circuit pattern is complete, the electrical and mechanical parameters of the flexible printed cable or harness can be specified for design-drafting (or submittal to manufacturer). At this point, a checklist of considerations is useful, Table 1.

Materials used in flexible printed wiring may be divided into three categories—base insulation, stiffening or rigidizing material (if required), and conductors.

**Base or Insulating Materials:** Temperature range, moisture-absorption characteristics, chemical inertness, flexing strength, tensile strength, electric strength, dielectric constant, aging effects, and cost are all important factors influencing the selection of a suitable base material. Table 2 lists the properties of several insulating materials available.

**Supporting Materials:** Careful consideration should be given to the effects of using a supporting material. Supporting or reinforcing materials can be

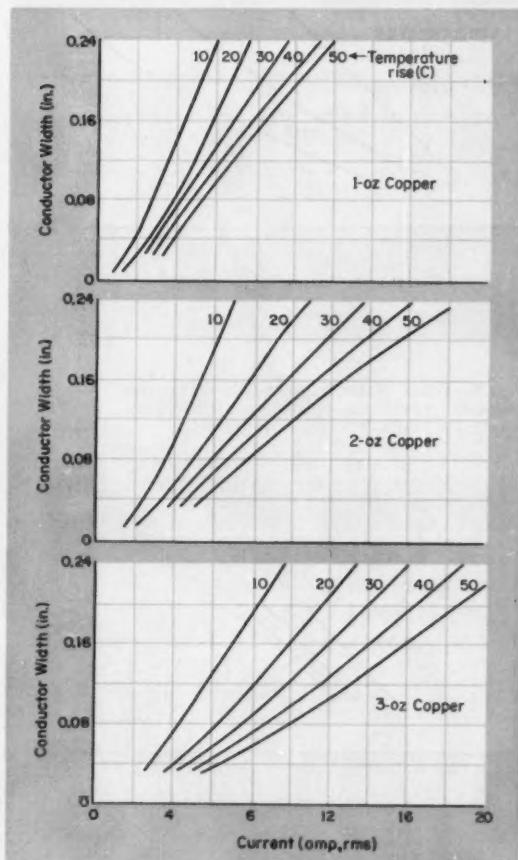


Fig. 6—Typical current-handling capability of various widths of single conductors insulated with Kel-F.

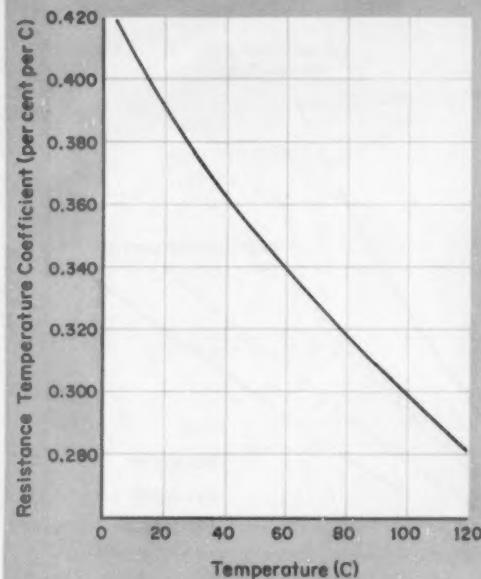


Fig. 7—Resistance temperature coefficient of pure annealed copper.

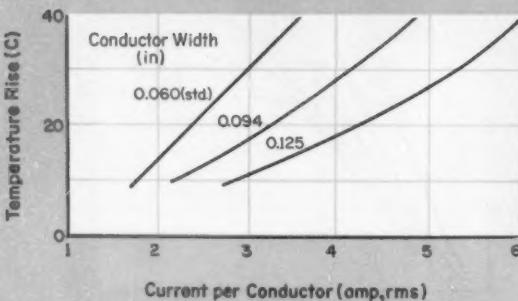


Fig. 8—Effect of conductor width on current-handling capabilities. Conductor dimensions, except for width, are shown in Table 4.

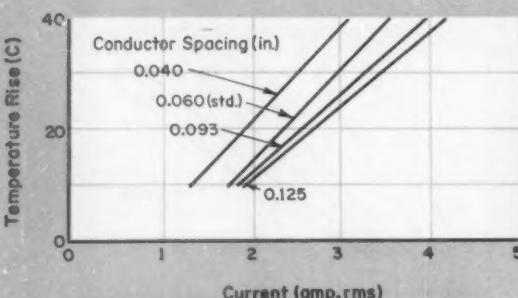


Fig. 9—How conductor spacing affects current-carrying capacity. Dimensions from Table 4.

bonded to flexible printed wiring to provide dimensional stability, rigidity, mechanical support, better resistance to abrasion, or shielding. Glass cloth, metal mesh, sheet metal, or many types of thermosetting plastic boards are materials which may be used.

**Conductors:** Rolled copper foil of greater than 99 per cent purity is normally used for conductors and shields, although other grades may be employed. Table 3 shows the usual weights and thicknesses of copper foil, but thicker and thinner foils are available.

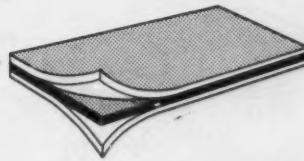
## Conductor Width and Spacing

Conductor widths and thicknesses are determined chiefly on the required current-carrying capability. Because a selection of copper thicknesses is available, this capability may also represent a compromise between flexibility and minimum line width—the thicker the copper, the smaller the width for a given current-carrying capacity. Fig. 4 shows the resistance and equivalent wire size for various weights and widths of copper.

Width-to-thickness ratio of conductors should be six or more, and conductors should have a minimum width and spacing of 0.025 in. By observing these

Table 2—Properties of Insulating Materials

Property	Vinyl	Polyester-Polyethylene Laminate	Kel-F	Teflon FEP
Dielectric strength (v/mil, 5-mil film)	1850	1700	1500	2000
General working-design dielectric strength (total v, 5-mil film)	1000	1000	1000	1000
Embrittlement temperature (°C)	-2	-55	<-84	<-85
Heat dissipation factor (Btu/hr/sq ft/F/in.)	No Data	1.8	0.42	1.35
Upper temperature limit (°C)	120	110	189	230
Specific gravity	1.2	0.99	2.1	2.15
Dielectric constant at room temperature for 1 kc	5.7	2.4	2.7	2.1-2.2
Water absorption (per cent)	0.2	Negligible	Nil	Nil
Recommended continuous operating temperature (°C)	0 to 100	-50 to +100	-60 to +140	-85 to +200
Tensile strength at 73 F (psi)	3300	4000	5700	2700-3100
Relative cost of basic plastic	1	2	20	25
Relative cost of material in finished circuit	1	1.1	1.50	2.00



arbitrary limits, the designer can automatically eliminate many production difficulties.

When these minimum figures cannot be adhered to, conductor widths as small as 0.010 in. are possible, and even narrower lines can be held for subminiature applications. Careful artwork is of key importance when working to these fine line dimensions, and special problems might still arise.

Wire size, or conductor width and thickness may affect permissible temperature rise. Other factors that should be considered are type and thicknesses of insulation, supporting materials, number of layers, number of conductors per cable, and environments. In general, the printed conductor shows a better temperature rise characteristic than its equivalent wire size, because the flatness of the printed conductor gives a better exposed-surface-to-volume ratio for heat dissipation.

Some clear comparisons of temperature rise for commonly used sizes are shown in Fig. 5. Fig. 6 shows typical current-handling capability of the

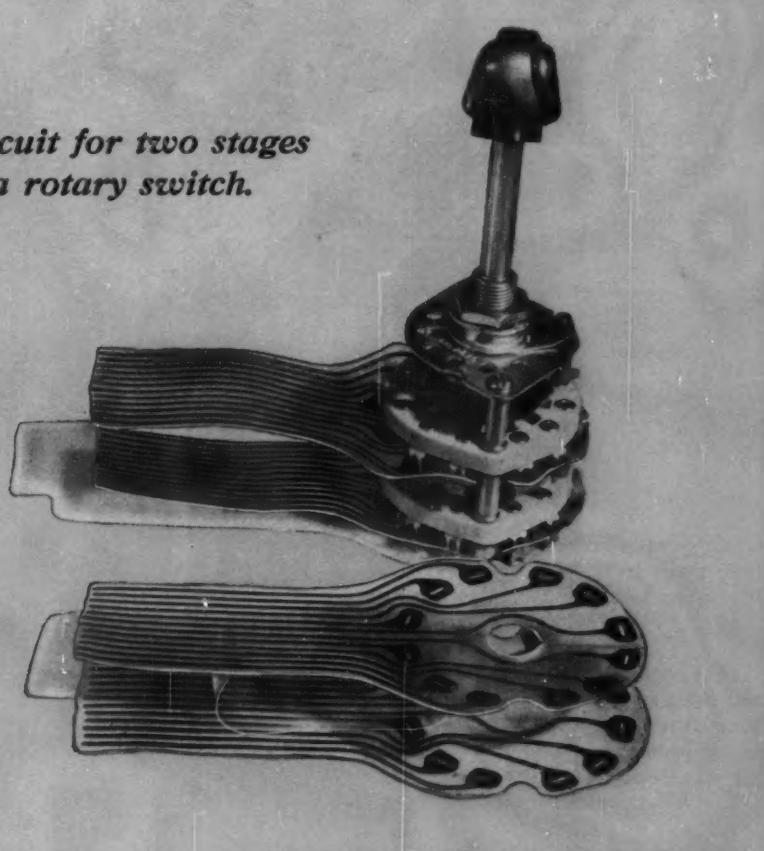
**Table 3—Weights and Thicknesses of Copper Foil**

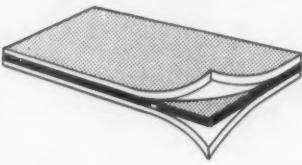
Weight (oz/sq ft)	Thickness (in.)
1	0.00135
2	0.0027
3	0.0040
5	0.0068
7	0.0094
—	0.010
—	0.015
—	0.020
—	0.030

**Table 4—Composition and Dimensions of Standard Test Cable**

Conductor material	Rolled copper
Conductor width	0.060 in.
Conductor thickness	0.0027 in.
Number of conductors	10
Spacing between conductors	0.060 in.
Insulation material	Kel-F
Insulation thickness:	
Base	0.005 in.
Cover coat	0.006 in.

*Circuit for two stages  
of a rotary switch.*





FLEXIBLE PRINTED CIRCUITS

most frequently used copper widths and thicknesses insulated with Kel-F.

The current,  $I_2$ , required for a given temperature rise at some high ambient temperature is

$$I_2 = I_1 \left( \frac{R_1}{R_2} \right)^{\frac{1}{\alpha}}$$

where  $I_1$  = current required for the same rise at a lower ambient temperature, amp;  $R_1$  = resistance of the copper at the lower ambient temperature, ohms per ft;  $R_2$  = resistance of the copper at the higher ambient temperatures, ohms per ft.

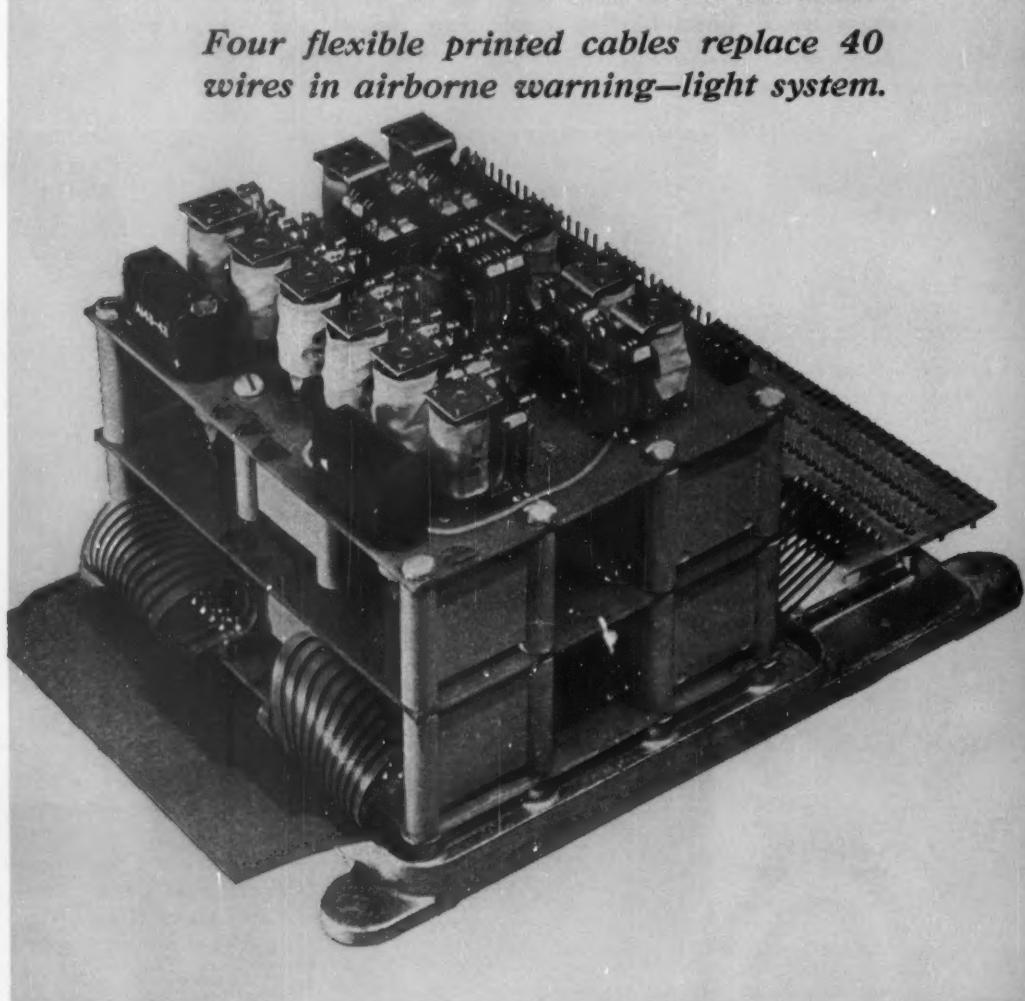
Fig. 7 shows the variation of the resistance temperature coefficient with temperature for pure annealed copper. If the resistance,  $R_1$ , at any temperature,  $T_1$ , is known, the resistance,  $R_2$ , at any other temperature,  $T_2$ , may be determined by

$$R_2 = R_1 [1 + \alpha (T_2 - T_1)]$$

where  $\alpha$  = resistance temperature coefficient of the copper at  $T_1$  from Fig. 7, per cent per deg C.

Fig. 8, 9, and 10 illustrate the effect upon current-carrying capability of several parameters of a test cable. Composition and dimensions of the standard test cable are given in Table 4.

**Flashover Voltage:** Flashover or arcing between exposed conductors is a function of conductor spac-



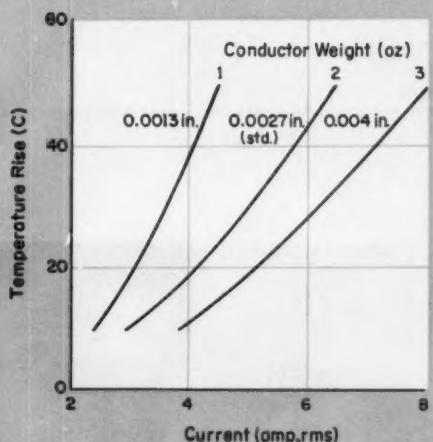


Fig. 10—Effect of conductor thickness on current-handling capabilities. Dimensions from Table 4.

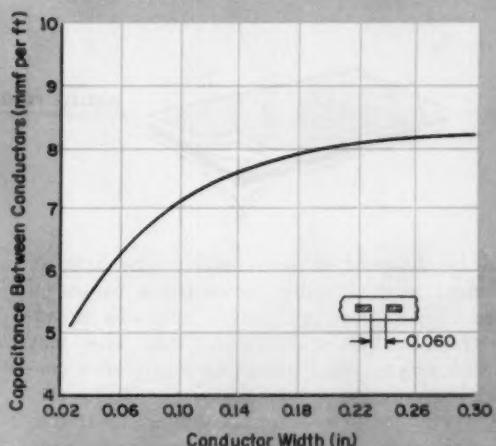


Fig. 12—Capacitance between adjacent copper conductors in the same plane.

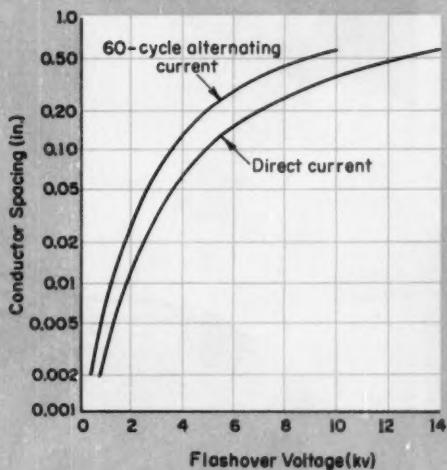


Fig. 11—Flashover tendency of exposed copper in air.

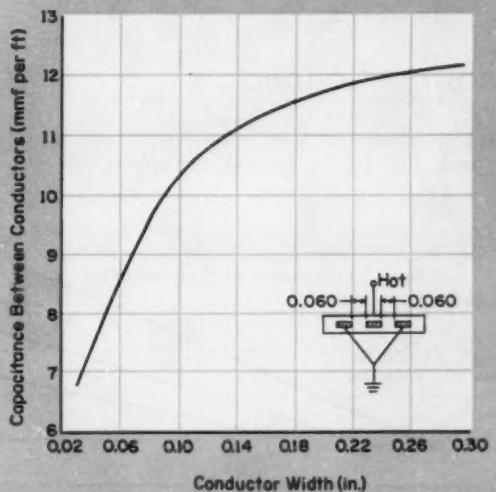


Fig. 13—Capacitance between center conductor and two grounded adjacent conductors.

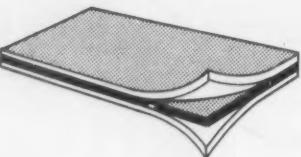
Table 5—Dielectric-Constant Ratio of Materials to Kel-F

Material	Ratio
Teflon FEP .....	0.89
Polyester-polyethylene plastic .....	0.92
Irradiated polyethylene .....	0.93
Silicone rubber (Silastic 8) .....	1.21

ing. Exact values depend on humidity, atmospheric pressure, and other factors. Fig. 11 shows typical curves of flashover voltage for exposed copper in air at ground level.

**Capacitance:** Fig. 12, 13, and 14 show capacitance between conductors at 1 mc in standard test cables with Kel-F insulation. To find capacitance of other plastics, multiply the capacitance values from these figures by the dielectric-constant ratio for the particular material from Table 5.

**Terminations:** Shape of conductor terminations



should be designed to accommodate the form of attachment used. Usually, terminations consist of exposed copper areas or "pads," perforated to admit a connector pin or component lead. They may be placed at any point along the length of a conductor. Cable design should always provide for adequate spacing between terminal and adjacent conductors. Round terminating pads are most commonly used, but close spacing may necessitate using elongated, narrower shapes. Adequate area should be provided to ensure that the pad is entirely clear of insulation, thus providing enough copper for a good solder fillet. Typical terminations are illustrated in Fig. 15.

## Choosing Connectors

Many standard and nonstandard connectors have been used, Fig. 16. In general, connectors can be

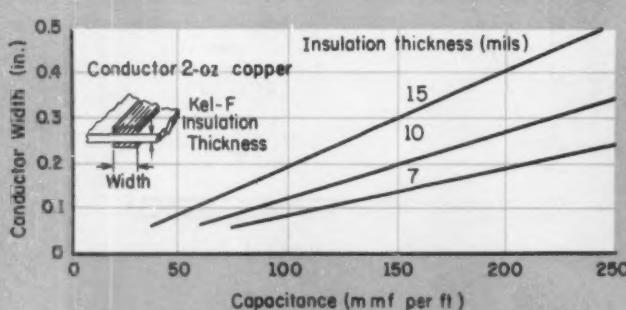


Fig. 14—Capacitance between stacked conductors.

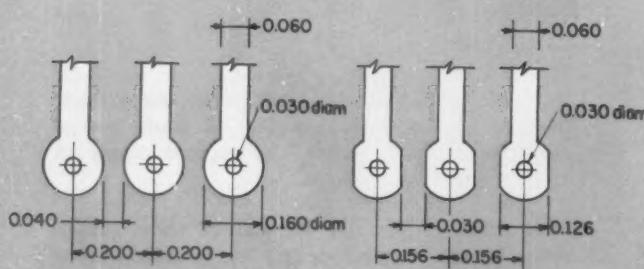
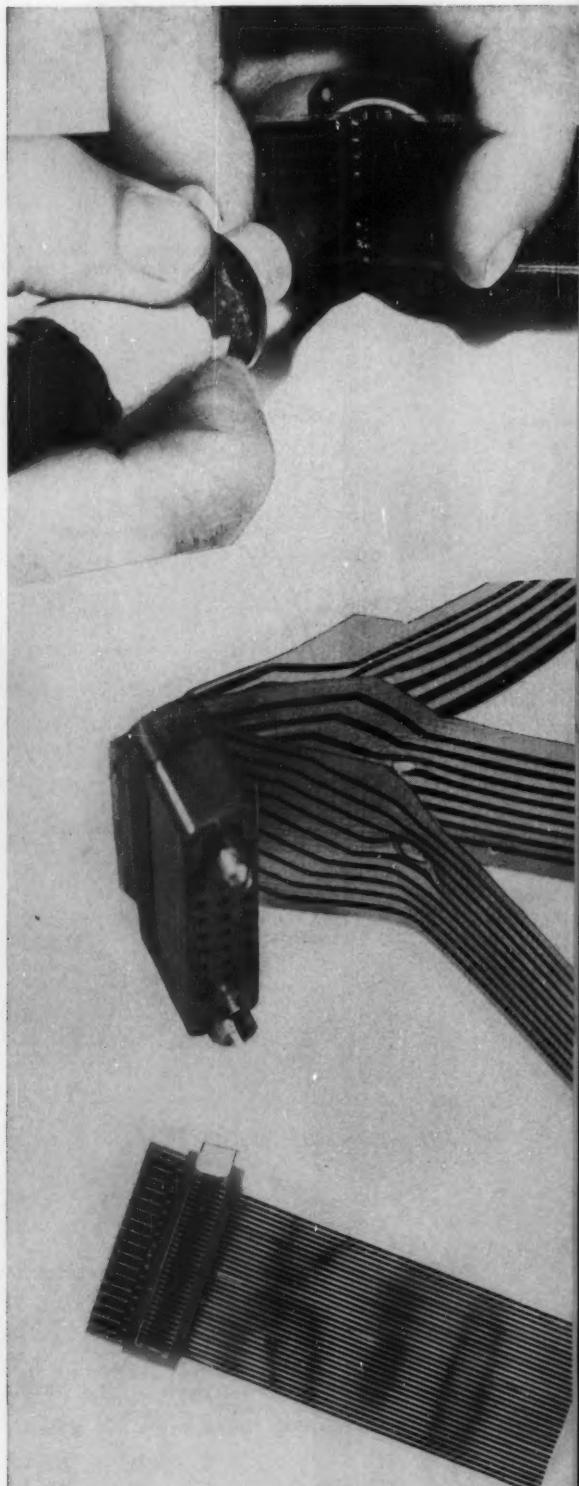
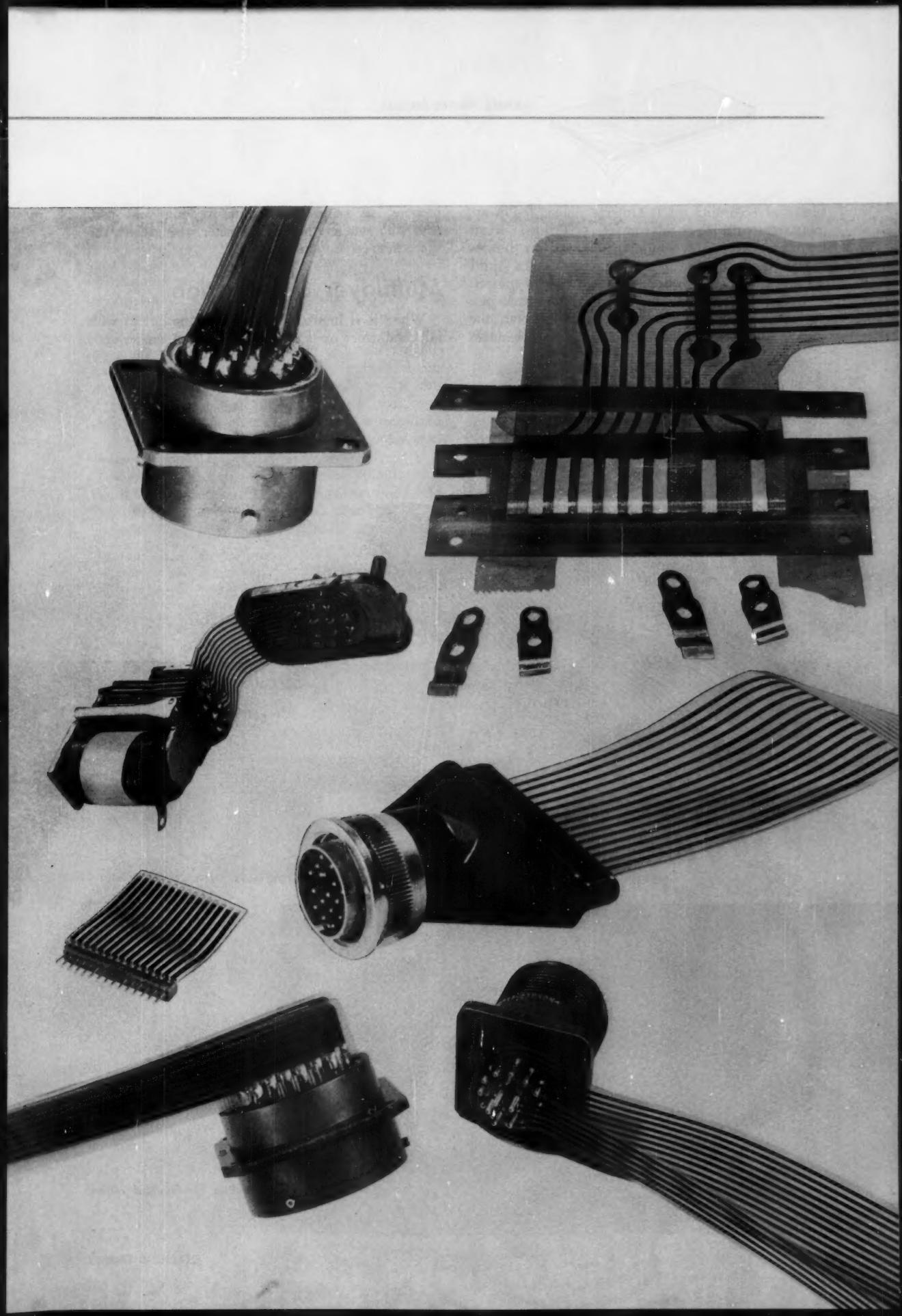
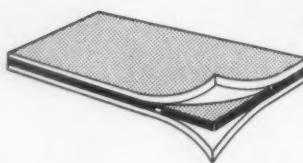


Fig. 15—Dimensions of typical terminations.

Fig. 16—Standard connectors adapted for use with Flexprint wiring.







FLEXIBLE PRINTED CIRCUITS

classified according to: 1. Outside shape. 2. Pin arrangements. 3. Type of contact. 4. Printed circuit connectors. The only limitation imposed on the designer using flexible printed circuits is the third classification in the foregoing listing—type of contact.

If contacts can be modified to a solid-back pin, it follows that the smaller the pin diameter, the greater the effective solder-pad size, and tolerances

become less critical in registering hole and pad. Also, the smaller the pin diameter, the greater the space between conductors.

## Multilayer Construction

When it is impractical to design the circuit with all conductors on a single surface (no crossovers),

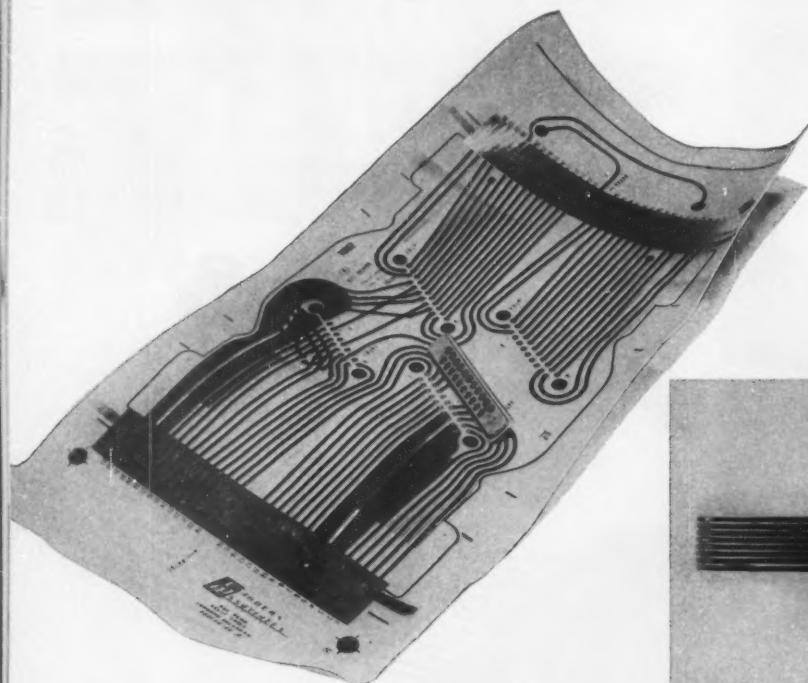


Fig. 17—Complex, multilayer-circuit assembly.

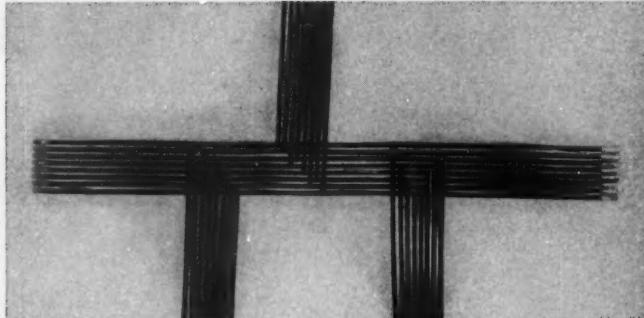


Fig. 18—Cable with feeder arms branching out from inside conductors.

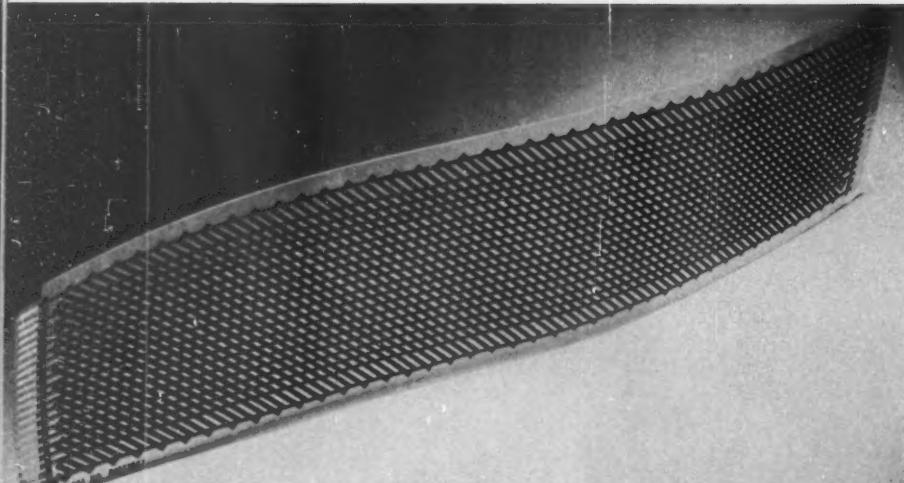


Fig. 19—Shielded cables.

multilayer construction of the flexible printed circuit may be used. Also, when exceptionally high wiring density, shorter routing of interconnections, smaller circuit area, shielding (beyond grounding of adjacent conductors), or stiffening of the circuit is needed or desired, this construction may be employed.

Layers are insulated from each other, and may be either laminated together, or left separate and joined through connectors at the termination. Important work simplification in assembly results from using one part instead of two, three, or four separate pieces. The circuit may require interconnection between layers. Fig. 17 shows a complex, multilayer-circuit assembly.

Again, the design of this type of circuit is the result of a number of trial layouts aimed at finding the most direct, efficient, and economical compromise. Two precautions should be observed:

1. Conductors on each layer must be routed, and terminations and components located, so that no terminations are superimposed on another layer.
2. If interconnections are to be made between layers,

artwork must be prepared for both layers with points of interconnection in register—this is easily accomplished through use of a transparent plastic overlay.

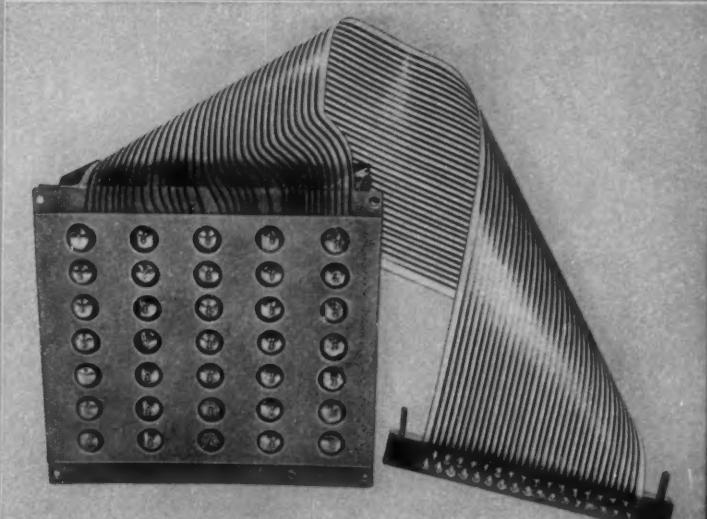
Fig. 18 shows a cable with feeder arms branching out from the inside conductors. This is a form of multilayer cable in which the feeder connections have been spot welded to the main lines, and the welded area has been covered with plastic insulation.

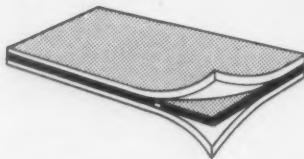
Various types of shielding can be designed to provide flexibility. Lattice shielding with the lattice structure running across the conductors at an angle of 45 deg is effective and permits sharp bending of the shielded cable. A solid shield can be used where electrical conditions demand it, and where minimum flexing or bend radius is required. Fig. 19 shows shielded cables, and Fig. 20 shows a simulated twisted pair.

## Dimensional Tolerances

Artwork should be planned with the same considerations that apply to designing hardboard printed

*Flexible printed harness attached to terminal board.*





FLEXIBLE PRINTED CIRCUITS

circuits made with thermosetting plastic. If the tolerances can be maintained, a 360-deg solder fillet at connections can be practically guaranteed.

Generally, tolerances of  $\pm 0.005$  in. per in. of width can be held. For larger sections, tolerances of  $\pm 1/16$  in. per ft are practical. Pieces running 1 ft or longer should be laid out with a tolerance of  $+1/8$ ,  $-0$  in. per ft. It is good practice to design to "the long side" of these dimensions. All solder pads should be designed as large as possible, and yet consistent with circuit characteristics that dictate available space.

A variety of methods will assure accurate alignment of flexible circuits with connectors and components. These methods include:

1. Ends of cable are slit lengthwise to allow enough side-to-side "play" for positioning termination pads.
2. A negligible amount of cable length is added to overcome any critical dimensions in the longitudinal direction. When holes are matched to pins, the extra length is absorbed in an indecipherable catenary or

- ripple.
3. Either standard or oversize termination pads are drilled or punched eccentrically to match connector pins.

## Preparing Artwork

A drawing material having the dimensional stability of plastic-impregnated glass cloth should be used. All lines in the artwork must appear dense and opaque to the camera, and have sharply defined edges. Sharp-line, ink drawings are satisfactory, but any voids left in the ink drawing appear in the finished circuit; ragged edges on the conductors detract from appearance and might show up under high-voltage tests with misleading results.

For small areas, use of black, pressure-sensitive adhesive tape for artwork is fast and effective. For large areas, a translucent red film on a transparent carrier sheet is available commercially. Conductors

Fig. 20—A Flexprint simulated twisted pair.



are outlined on the red film, and a sharp knife is used to cut along the outline. The film between conductors is simply removed to produce a finished drawing. Master artwork may be a composite of the black tape lines and red film. This is a good method for producing rounded corners and odd-shaped conductors or pads.

Corners, especially inside corners, should be rounded. One dimension, preferably the longest, should be indicated as a guide to proper reduction. Registration marks on the master artwork are necessary throughout the production process to key the positioning.

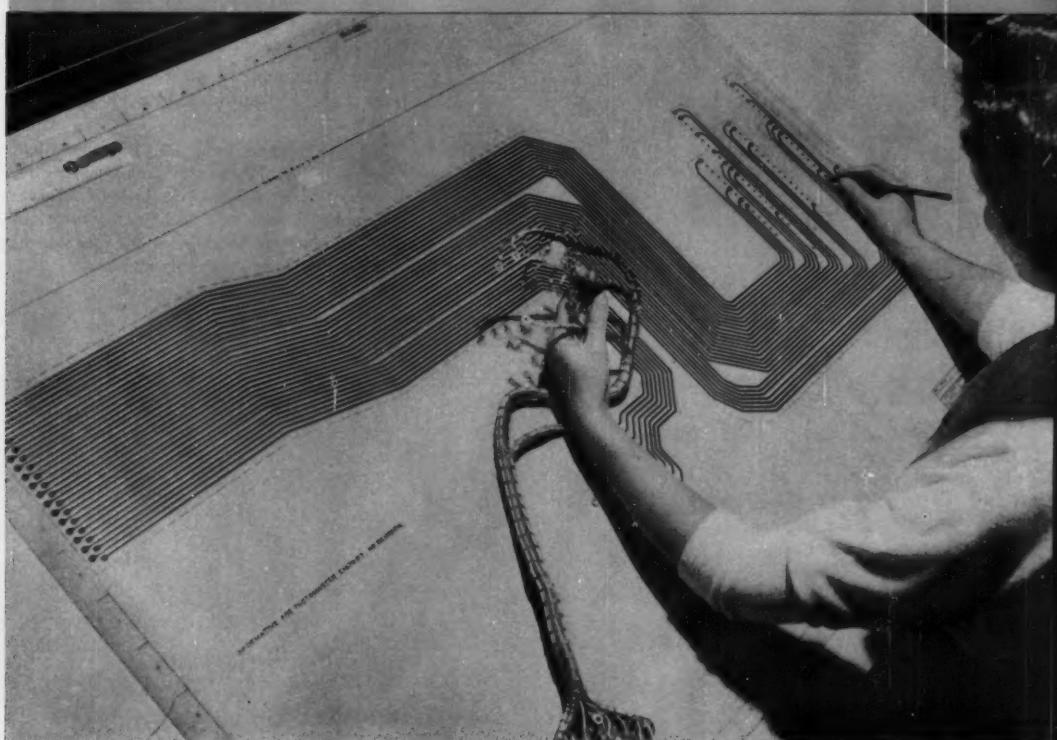
Artwork is usually made up to four or more times the actual size of the finished circuit. Finished size, size of conductors, accuracies required, and limitations of camera equipment are determining factors. For small pieces, it is sometimes convenient and more accurate to make the artwork larger than four times actual size in laying out lines and spaces, Fig. 21.

Large drawings, exceeding camera dimensions, may be made in sections. These can be reduced photographically, and the negative spliced to produce the finished circuit. Negatives should be butted when splicing is necessary. A contact print can be made to produce a single piece, with all splicing marks or overlapping of film removed.

If a number of identical conductor patterns must be made, the negative may be prepared from a single piece of art through use of a step-and-repeat camera procedure. Patterns may be either continuously repeated (long cables), or prepared for die-cutting into separate units.

Since printed-circuit etching processes are used in fabricating flexible printed wiring, everything appearing on the artwork can be reproduced in the finished wiring assembly. Consequently, it is only necessary to add such numbers, letters, or other markings at appropriate points to identify the circuit or individual conductors.

Fig. 21—Design drafting of a flexible printed cable for photographic reduction.



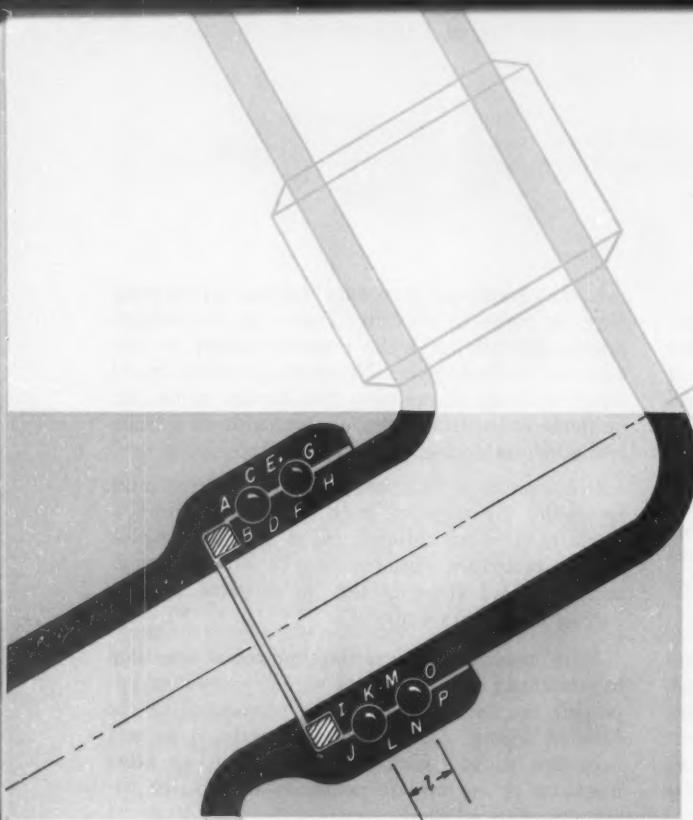


Fig. 1—Internal construction of typical swivel joint.

# Hydraulic

**S**WIVEL systems—a series of straight or curved pipes connected by swivel joints—provide a flexible, all-metal pipe connection. Their applications range from the high-pressure transmission of hydraulic fluids to undersea oil pipe lines in the Gulf of Mexico.

Two outstanding characteristics make swivel systems valuable supplements to hydraulic hoses:

1. They form a leakproof, low-torque connection between a stationary pipe and a moving piece of equipment when temperature, pressure, space, or flexibility problems arise.
2. They help relieve stresses imposed by thermal expansion, vibration, or misalignment.

## G. M. BAGNARD

Chief Engineer  
Brea, Calif.

Chemical Corp.  
Subsidiary of Food Machinery and  
Chiksan Co.

# Swivel Systems

combine the strength of pipe  
with the flexibility of hose.  
Here are their geometric characteristics.

The key element in any swivel system is, of course, the swivel joint itself. Used singly or in multiple groups, swivel joints establish both the flexibility and design limitations for the system. Properly employed, swivel joints can give maintenance-free service. Misapplied, they can result in excessive initial cost, or premature failure.

## *The Swivel Joint . . .*

The important first step in designing swivel systems is to recognize the swivel joint for what it is: a precision mechanical component.

Most machine applications for swivel joints involve

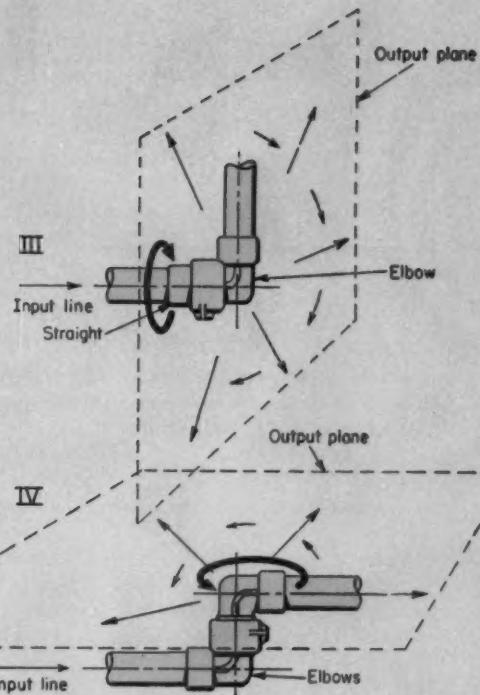
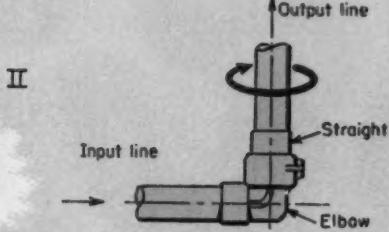
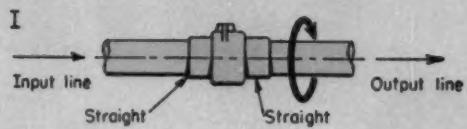


Fig. 2—Four basic swivel-system arrangements.

Type I—System with straight connectors on both sides of swivel joint. Input line is the line in space established by the last pipe in the system before the joint. This line is usually assumed fixed in analysis of a swivel system. The center lines of input and output connectors coincide with this input line. Hence, the output line of the system is a line in space around which the output pipe can revolve on its own axis.

Type II—System in which the input connector is an elbow and the output connector is straight. Swivel races are parallel to input line, rather than perpendicular to it. The result is an output line that is perpendicular to the fixed input line.

Its exact position in space is established by the fixed elbow. The only motion available is the simple revolution of the output pipe.

Type III—System in which input connector is straight and output is an elbow. The output of the system becomes a plane perpendicular to the input line. The output pipe may lie in any position in this plane. Regardless of the position that the output pipe takes, it is always perpendicular to the input line.

Type IV—System in which both input and output connectors are elbows. The result is an output plane that is parallel to the input line. Again, the output pipe may lie anywhere in this plane. The location of the plane is fixed by the fixed input elbow.

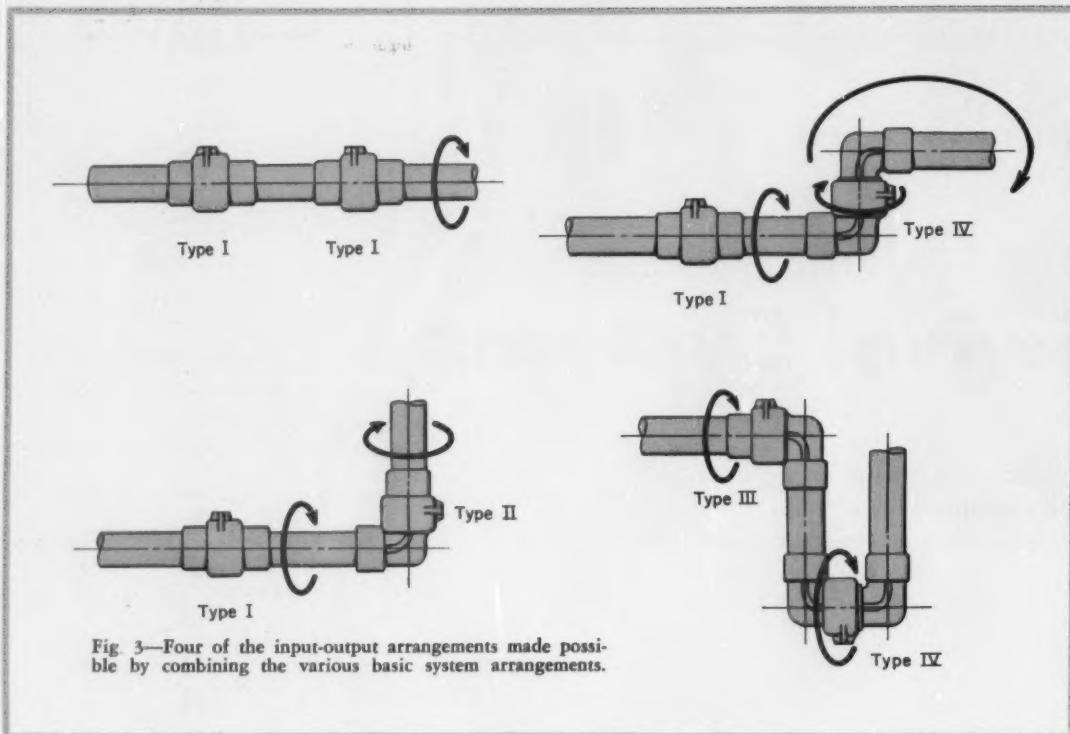


Fig. 3—Four of the input-output arrangements made possible by combining the various basic system arrangements.

equipment that already contains parts which revolve, slide, or oscillate. The swivel system is part of this moving machinery. Consequently, the swivel joints, normally specified as a "package," should be selected and applied with the same care given to bearings, valves, shafts, and other precision machine elements.

**Moment Loads:** Fig. 1 shows the internal construction of a typical swivel joint. Most commercial joints contain two rows of ball bearings, rolling in ball-bearing races that are rough machined and then ground as integral parts of the pipe sections that form the joint.

All tension loads on the swivel are borne by metal surfaces *B*, *C*, *F*, and *G*, (for balls at the top) while thrust loads are carried by surfaces *A*, *D*, *E*, and *H*. Occasionally, the primary load on the swivel is shear. Then the load in a typical case is evenly distributed over the surfaces on one-half of the swivel-race circumference.

In addition, a moment load is sometimes developed. If a downward force is applied, for example, to the outer end of the right-hand element, extra heavy loads are carried by surfaces *B* and *C* at the top, and *N* and *O* at the bottom. The ability of the joint to withstand moment loads depends not only on the inherent strength of the joint material, but also on distance *L* between the rows of bearings.

The leverage provided by distance *L* varies according to the type and size of joint. Where severe

moment loads are encountered, joints with an extra wide spread between races may be specified.

Joint recommendations generally indicate maximum pressure ratings for various sizes and configurations. Maximum moment load is more difficult to state, since it is usually combined with shear and other stresses. However, empirical methods have been developed for establishing safe moment loads in any given type of swivel system.

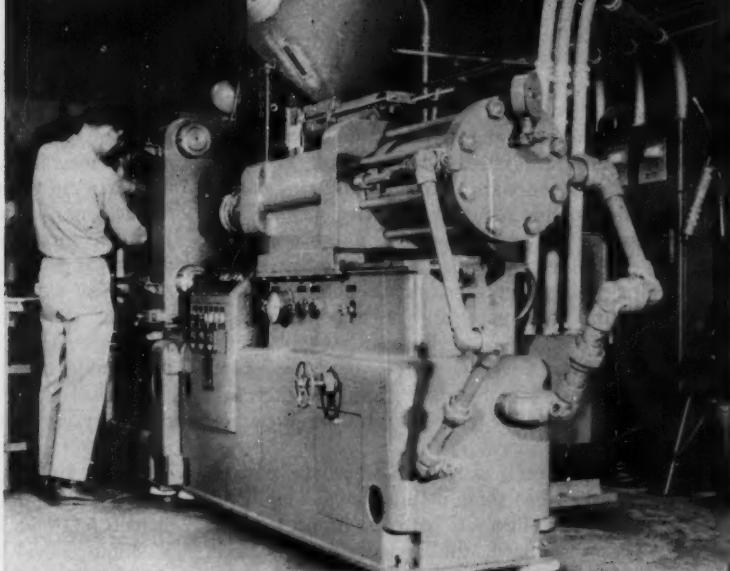
#### ... and Its Application

The simplest swivel system is one involving two connecting lengths of pipe (an input and an output) and a single swivel joint. Even at this low level of complexity, however, a number of arrangement choices are available to the designer.

The input connector may, for instance, be either a straight length of pipe or a 90-deg elbow. Other angles can be used, but are not usually available in units of standard design. The output can also be a straight pipe or an elbow. Thus, four different combinations of input and output connections are immediately possible, each establishing a different input-output relationship.

These four combinations are shown in Fig. 2. In the case of type I and II, the output is a *fixed line* in space, with the output pipe revolving around its own axis. For combinations III and IV, the output

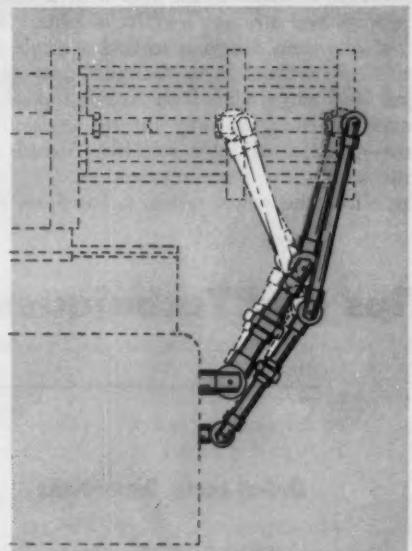
# Flexibility and Shock Endurance



**Flexibility and shock endurance . . .** are required every time the ram of this Reed-Prentice injection molding machine moves forward, the pressure within the hydraulic system rises abruptly from zero to over 2000 psi.

The result is repeated shock on the hydraulic supply lines. Yet, one requirement of the design is that these lines be flexible. The entire feeding end of the machine, including the hopper, the hydraulic ram, the heater, and the stationary platen, must move back and forth on tracks to accommodate various mold sizes.

Since the alignment of the moving portion of the machine remains constant, swivel joints with single-plane swivels could be used. The two pipe lengths that make up each flexible line move in separate, but parallel planes. There is no twisting action around the moving elbow. Two swivel joints at the end of the hydraulic cylinder provide a 90-deg swinging action. The remaining four joints are combined with two elbows, joined by a single swivel, to provide 360-deg action in parallel planes.



is a *plane of motion*, in one case perpendicular to the input line, and in the other, parallel to it.

**Family of Planes:** The four arrangements, I, II, III and IV, Fig. 2, represent the basic building blocks of any swivel system.

A two-swivel system offers, then, 24 different combinations of input-output arrangements. A few of these are shown in Fig. 3. They range from the nearly meaningless combination of two I's, which results in an extension of the single line of revolution established by the first swivel, to the versatile combination of a III and IV, which produces a family of output planes. These planes have a common characteristic: They are parallel to the interconnecting line between the two swivels, and this line, in turn, is perpendicular to the input line.

The perpendicularity and parallelism of the lines

and planes that make up the connecting parts of a swivel system are an essential characteristic of swivel-joint design. Furthermore, as more swivels are added to the system, the output flexibility grows dramatically. In fact, with seven swivels and suitable elbows, a system may be built with universal flexibility.

The job is to find the system with the right number and combination of swivel joints to provide the necessary flexibility—and no more. A good rule of thumb is to provide the number of swivels that are theoretically necessary, plus one extra. However, too many swivels can defeat the efficiency. The extra unit, usually a straight-line swivel (arrangement I) at the input or output of the system, absorbs the torsional stresses by misalignment.

**Combinations for Flexibility:** The foregoing de-

scriptions of one and two-swivel arrangements give the basic rules for system design. But, knowing the rules is not enough. Considerable ingenuity and imagination are required to arrive at the best combination of swivels and elbows to provide the necessary flexibility.

Assuming that more than simple rotary motion is involved, the best approach is to stop the motion of the proposed system at its two extreme positions. Some systems have three, four, or more extreme positions, but these are usually either intermediate positions, or can be taken as separate problems.

In any case, at each extreme position the output line of the system has some definite spatial relationship with the input line. If both the input and the output lines were fixed, the designer would have no trouble connecting the two with a combination of elbows and straight lengths of pipe. The trick in swivel-system design is to find a single combination of elbows and pipes that will serve to connect input and output in both extreme positions, the connection changing only in the angles that exist between individual pipe sections. Swivels at these joints permit the necessary motion.

In effect, the swivel system is based on, and com-

pensates for, the difference in spatial relationships as the machinery or other equipment moves from one extreme position to another. This spatial difference may take the form of a differing distance between input and output, or the arcing of the output at a fixed distance from the input, or the revolution of the input or output. In the latter case, the axis of revolution may coincide with the input line, or remain parallel to it, or vary in some unpredictable manner.

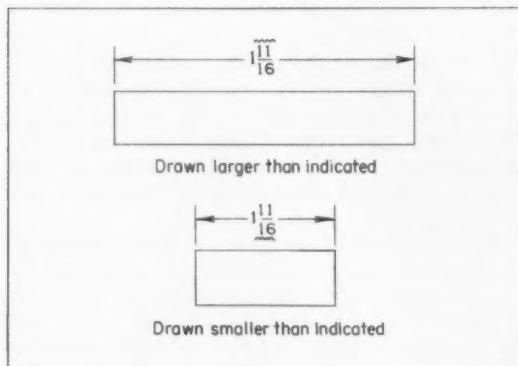
Each of these cases requires a different type of swivel system. Where the distance between input and output changes, a dog-leg is normally required. The two straight lengths of pipe that make up the dog-leg move in parallel planes, separated by the swivel joint between them (presuming that only a single swivel is included in this joint). Additional elbows and swivels are therefore required if input and output lie in planes other than those established by the dog-leg sections.

Rotary motion is handled by straight-through swivels. But a straight-through swivel presumes exact alignment of input and output, and rarely will this be the case. To prevent whipping within the joint, extra swivels and elbows are required, providing, in effect, a universal-joint connection.

## Tips and Techniques

### Out-of-scale Dimensions

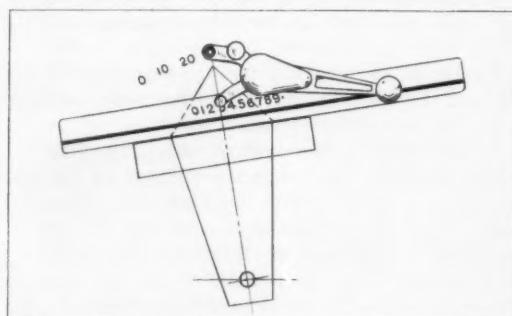
A handy method of marking out-of-scale dimensions tells the reader whether the drawing is larger or smaller than the indicated size. The wavy line



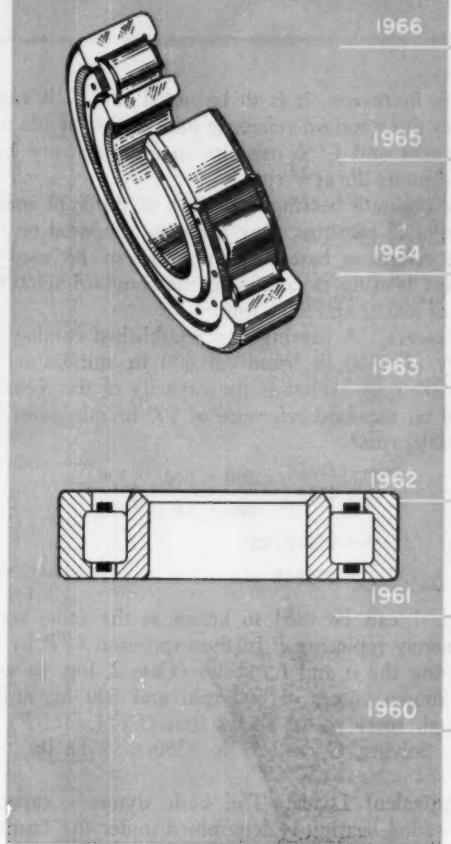
over the dimension indicates the part is drawn larger than the dimension, the line under shows it is drawn smaller.—LEO B. WESSELL, design engineer, Planet Products Corp., Cincinnati, Ohio.

### Lettering on Arc

LeRoy lettering or numbering on an arc can be controlled conveniently with a cardboard guide. Two strips are joined at right angles as shown, and a thumbtack is used for a pivot. In use, the pointer of the guide is moved to point each letter or number.  
—LEO KULL, General Time Corp., New York, N. Y.



*Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.*



## How

- vibration
  - shock
  - variable loads and speeds
  - thrust
- affect

# Roller-Bearing Life

**W**HEN loads are steady, no great problems exist in selecting the proper bearings. But what happens when shock loading, vibration, and other unusual conditions are present?

First, a "basic" load is determined—usually a simple matter. Then, the basic load is modified by factors determined by the type and application of bearing load.

**Basic Bearing Life:** The basic roller-bearing life formula is

$$L = \left( \frac{C}{P} \right)^{10/3} \quad (1)$$

If the external bearing load,  $P$ , is known and a given bearing with a dynamic capacity,  $C$ , has been selected, the minimum life in millions of revolutions can be calculated easily by means of Equation 1. Alternately, when a given minimum life is desired and the external bearing load is known, then solving for capacity with the aid of a bearing manufacturer's catalog will indicate the bearing required.

In many applications, the minimum life in hours,  $L_H$ , at the known speed of operation,  $n$ , is required. Introducing these factors into Equation 1,

$$L_H = \left( \frac{C}{P} \right)^{10/3} \left( \frac{10^6}{60n} \right) \quad (2)$$

This equation is frequently written to incorporate the ASA standard life-hour reference base of 500 hr.\* Using this value to replace the constants in

\*Method of Evaluating Load Ratings for Ball and Roller Bearings, ASA Standard B3.11-1959, American Standards Association Inc., New York.

the last expression, the standard speed reference base becomes  $33\frac{1}{3}$  rpm, and the equation then appears as

$$L_H = \left( \frac{C}{P} \right)^{10/3} \left( \frac{500 \times 33\frac{1}{3}}{n} \right) \quad (3)$$

A graphic representation of this equation is given in Fig. 1, using the  $10/3$  exponent in the basic life rating—as recommended by ASA.\* Hence, the nomogram represents latest practice, instead of being based on the now-superseded exponent of 3.

Equation 3 or Fig. 1 can be used for rapid solution of minimum life in hours,  $L_H$ , based on a known ratio of dynamic capacity to external load,  $C/P$ , and a known operating speed,  $n$  (see Case 1, Fig. 1). Conversely, for a given required life-hour,  $L_H$ , at a known operating speed,  $n$ , the ratio  $C/P$  is thereby determined, and the bearing which is to be subjected to an external load,  $P$ , can be selected to satisfy this ratio (see Case 2, Fig. 1).

**Comparative Capacities:** The ASA specifies that bearing load ratings, if given for specific speeds, are to be based on a rating life of 500 hr. Consistent with the expression relating the ratio  $C/P$  to minimum life,  $L_H$ , at some speed,  $n$ , using standard base of 500 hr and  $33\frac{1}{3}$  rpm, Equation 3 may be similarly rewritten using any other base.

$$\frac{C'}{P'} = \left( \frac{L_H \times n}{L_{H'} \times n'} \right)^{3/10} \quad (4)$$

The other reference life-hour and speed bases must, however, exhibit the same power function relationship ( $10/3$ ) as that specified by the ASA. Combining Equations 3 and 4 and solving for  $C$ ,

$$C = C' \left( \frac{L_{H'} \times n'}{500 \times 33\frac{1}{3}} \right)^{3/10} \quad (5)$$

### Nomenclature

$C$	Basic dynamic load rating, lb
$C_0$	Basic static load rating, lb
$\epsilon$	Life dispersion exponent = 1.11
$f_0$	Service factor, shock
$f_T$	Service factor, thrust
$K_s$	Factor when $P_s > P_0$
$K_v$	Factor when $P_v > P_0$
$L$	Rating life, millions of revolutions
$L_H$	Rating life, hr
$n$	Speed, rpm
$P$	Equivalent radial load, lb
$P_0$	Shock or high radial load, lb
$P_A$	Permissible thrust load, lb
$P_s$	Steady radial load, lb
$P_T$	Thrust load rating, lb
$P_v$	Maximum amplitude of varying load, lb
$q$	Time, per cent
$t$	Time, sec, min, etc.

where, in review, it is to be noted that  $C$  is capacity to the standard reference base of 500 hr life and  $33\frac{1}{3}$  rpm and  $C'$  is capacity to any arbitrary base of  $L_{H'}$  hours life at  $n'$  rpm.

To evaluate bearing capacities of different makes or types of bearings, they must be compared on the same reference base. Equation 5 can be used to convert bearing capacities to the standard reference base of 500 hr and  $33\frac{1}{3}$  rpm.

**EXAMPLE:** A bearing has a published catalog capacity of 4350 lb based on 500 hr minimum life and 500 rpm. What is the capacity of this bearing based on standard reference of 500 hr minimum life and  $33\frac{1}{3}$  rpm?

$$C = 4350 \left( \frac{500 \times 500}{500 \times 33\frac{1}{3}} \right)^{3/10}$$

$$C = 4350(2.25)$$

$$C = 9788 \text{ lb}$$

Fig. 1 can be used to arrive at the same result by merely replacing  $P$  in the expression  $C/P$  by  $C'$ . Entering the  $n$  and  $L_H$  scales (Case 2, Fig. 1) with the known values of 500 rpm and 500 hr, a line through these points shows that  $C/C' (= C/P) = 2.25$ . Solving,  $C = 2.25 \times 4350 = 9788$  lb.

**Equivalent Loads:** The basic dynamic capacity of a radial bearing is determined under the assumed condition of the inner race rotating with respect to a constant radial load.

**POINT LOADING:** Since actual loading conditions vary from standard reference conditions, an effective or equivalent load is determined so that the basic life equation may be used. For applications where the inner ring is stationary with respect to the load, an equivalent radial load of  $1.2 P$  is used to convert "point loading" to "circumferential loading."

**DYNAMIC EFFECT FACTORS:** In any system of power transmission, certain dynamic effects are considered in realistically assigning an equivalent bearing load. The equivalent bearing load must be multiplied by one or more of the dynamic effect factors shown in Table I.

**THRUST:** Loads on a cylindrical radial roller bearing having guide flanges on the races may be both radial and thrust. In such a case the thrust loads are taken on different surfaces from those used for the radial loads. The presence of such a thrust load (when within recommended values) does not prejudice bearing life as forecast by Equation 1 when the calculated equivalent radial load is used. The familiar formula for equivalent load for radial roller bearings is

$$P = XF_r + YF_a \quad (6)$$

For a cylindrical radial roller bearing,  $YF_a = 0$  since any thrust load is not taken on radial load bearing surfaces. Also, the value of  $X = 1$  at all times, so Equation 6 reduces to  $P = F_r$ .

**Thrust Capacity:** Cylindrical radial roller bearings with integral guide flanges on races are capable

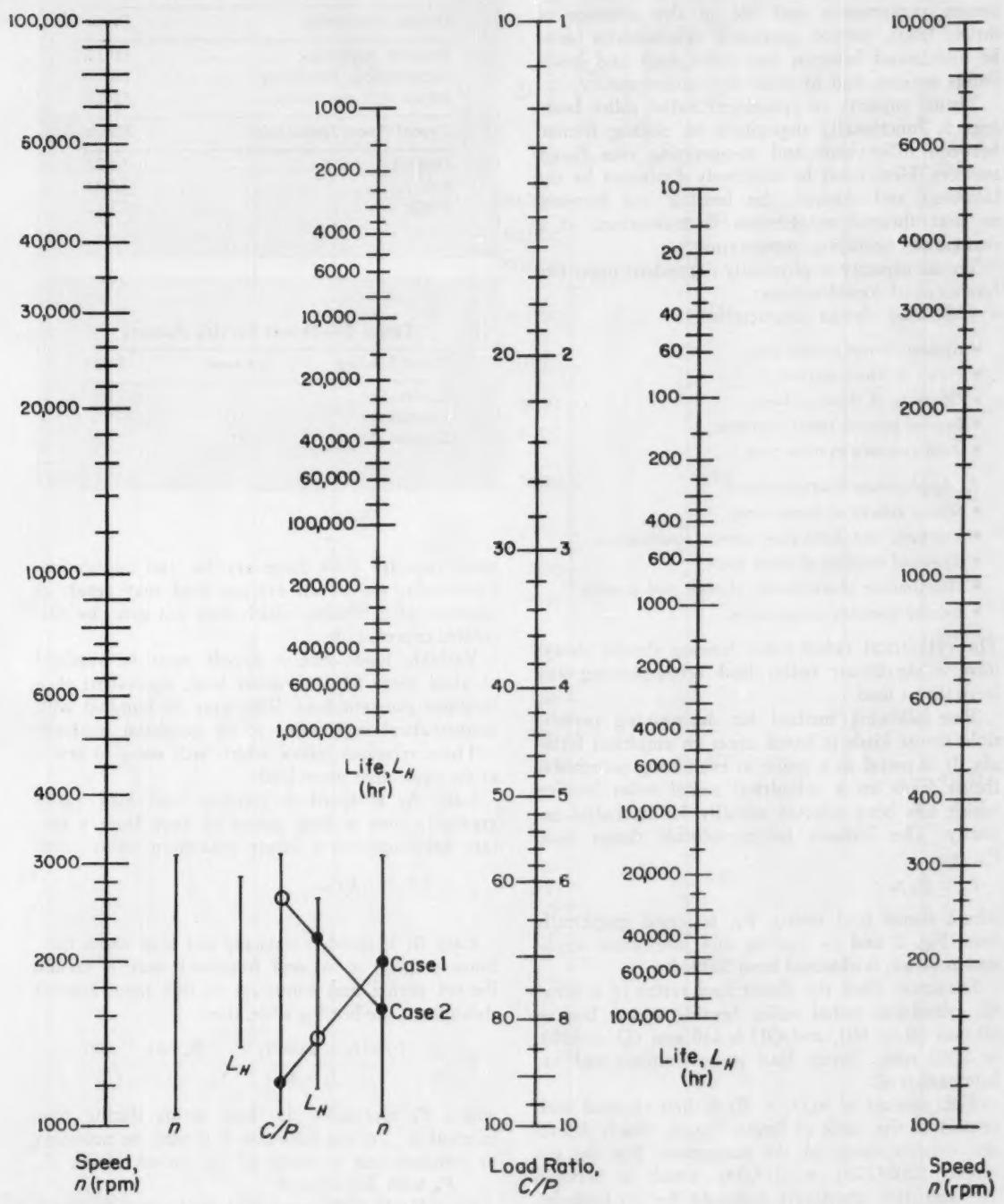


Fig. 1—Dynamic capacity and life for radial roller bearings.

of taking substantial thrust loads. To achieve optimum performance and life in the presence of thrust loads, certain geometric relationships must be maintained between race roller track and inside flange surface, and in roller end-squareness.

Thrust capacity of cylindrical radial roller bearings is functionally dependent on sliding friction between roller ends and co-operating race flange surfaces. Heat must be effectively dissipated by the lubricant and through the bearing and housing, so that thermal equilibrium is maintained at a reasonable operating temperature.

Thrust capacity is physically dependent upon two fundamental considerations:

1. Bearing design characteristics:

- Apparent thrust contact area.
- Finish of thrust surfaces.
- Geometry of thrust surfaces.
- Bearing internal radial clearance.
- Axial clearance in roller track.

2. Application characteristics:

- Sliding velocity at contact area.
- Lubricant and lubrication system specifications.
- Type and duration of thrust loads.
- Heat transfer characteristics of shaft and housing.
- Bearing operating temperatures.

The cylindrical radial roller bearing should always have a significant radial load accompanying any large thrust load.

The following method for determining permissible thrust loads is based upon an empirical formula. It is useful as a guide in evaluating permissible thrust loads on a cylindrical radial roller bearing which has been selected initially for its radial capacity. The formula for permissible thrust load,  $P_A$ , is

$$P_A = P_T f_T \quad (7)$$

where thrust load rating,  $P_T$ , is found graphically from Fig. 2 and  $f_T$ , loading and lubrication application factor, is obtained from Table 2

**EXAMPLE:** Find the thrust load rating of a Series 02 cylindrical radial roller bearing whose bore is 60 mm ( $B = 60$ ), and OD is 110 mm ( $D = 110$ ), at 2200 rpm. Thrust load is intermittent and the lubricant is oil.

The product of  $n(D + B)$  is first checked with respect to the table of limits, Fig. 2, which defines the validity range of the nomogram. For the example,  $2200(170) = 374,000$ , which is between  $10^4$  and  $10^6$ , the limits indicated for oil-bath lubrication. From Fig. 2, the value of  $P_T$  is then found to be 300 lb. Table 2 shows that, for the indicated conditions,  $f_T = 3.0$ . Using these values in Equation 7,  $P_A = 300 \times 3.0 = 900$  lb.

**Variable Load and Speed:** An easy, but unsatisfactory, way to solve problems of variable loads and speeds is to select a bearing adequate to handle the maximum load value. However, this usually results in the specification of a roller bearing which has

Table 1—Dynamic Effect Factors

General Application	Factor
Rotating machinery	1.0-1.2
Reciprocating machinery	1.2-1.5
Impact-type machinery	1.5-3.5
Type of Power Transmission	Factor
Gear	1.1-2.5
Belt	1.5-3.0
Chain	1.1-1.2

Table 2—Thrust Service Factors

Thrust Loading	$f_T$ Grease	$f_T$ Oil
Continuous	0.5	1.0
Intermittent	1.0	3.0
Occasional	3.0	5.0

more capacity than necessary for the application. Conversely, use of an average load may result in selection of a bearing which does not give the calculated expected life.

Variable loads and/or speeds must be resolved to yield some kind of mean load, equivalent to a fictitious constant load. This may be handled with mathematical expressions or by graphical methods.

Three relations follow which will serve to arrive at the equivalent mean load:

**CASE A:** If speed is constant and load varies gradually over a long period of time from a certain minimum to a larger maximum value, then

$$P = \frac{4P_{min} + 6P_{max}}{10} \quad (8)$$

**CASE B:** If speed is constant and load varies non-linearly (say, as a step function) over a certain limited period and continues in this same manner throughout the bearing's life, then

$$P = \left( \frac{P_1^{10/3} t_1 + P_2^{10/3} t_2 + \dots + P_n^{10/3} t_n}{t_1 + t_2 + \dots + t_n} \right)^{3/10} \quad (9)$$

where  $P_1$  represents the load acting during time interval  $t_1$ . To use Equation 9 it may be necessary to compute one or more of the values of  $P_1$ ,  $P_2$ , ...,  $P_n$  with Equation 8.

**CASE C:** If both speed and load vary, and each change in load is accompanied by a corresponding change in speed, then

$$P = \left( P_1^{10/3} \times \frac{n_1}{33\frac{1}{3}} \times \frac{q_1}{100} + P_2^{10/3} \times \frac{n_2}{33\frac{1}{3}} \times \frac{q_2}{100} + \dots + P_n^{10/3} \times \frac{n_n}{33\frac{1}{3}} \times \frac{q_n}{100} \right)^{3/10} \quad (10)$$

where  $P_1$  represents the load acting at speed  $n_1$ , and  $q_1$  represents time in per cent that  $P_1$  is act-

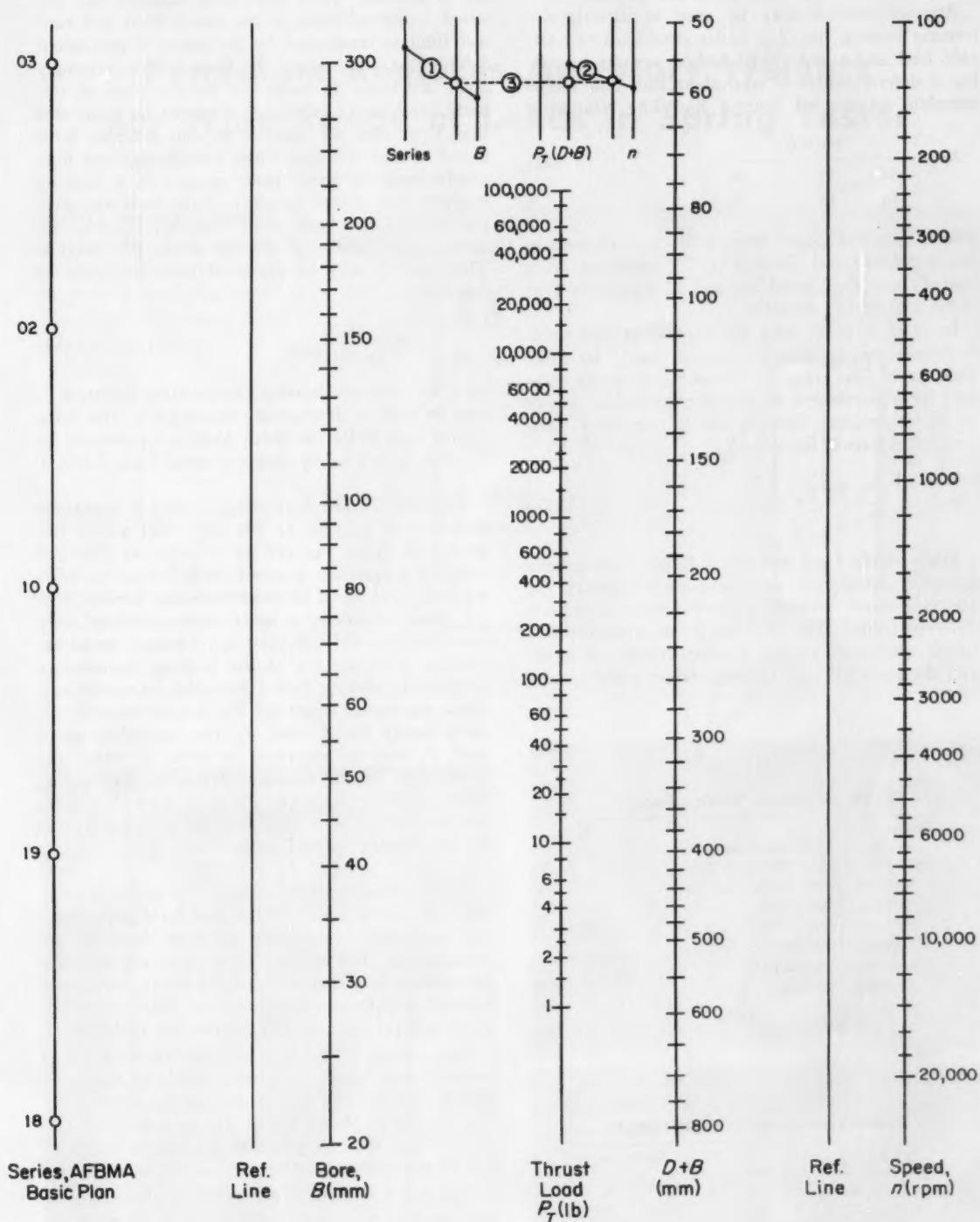


Fig. 2—Thrust load rating for radial roller bearings.

Limits for Using Fig. 2

	$(D+B)n$	
Lubrication	Min	Max
Oil bath	$10^4$	$10^6$
Grease	$10^4$	$5 \times 10^5$

ing at  $n_1$ . Total time must equal 100 per cent.

Another method may be used to directly determine bearing life,  $L_H$ , under conditions of variable load and speed. This method permits bypassing a determination of equivalent load and allows complete solution of bearing life. The relation is

$$L_H = \frac{100,000}{\frac{q_1}{L_1} + \frac{q_2}{L_2} + \dots + \frac{q_n}{L_n}} \quad (11)$$

where  $L_1$  is individual bearing life in thousands of hours (determined from Fig. 1), resulting from load  $P_1$  acting at speed  $n_1$ , and  $q_i$  represents time in per cent that  $P_i$  acts at  $n_i$ .

In cases A or B, after the equivalent load value is determined, bearing life may be found by using Equation 3. For case C, however, since the solution for equivalent load contains individual speeds in the expression, bearing life is calculated using a modified form of Equation 3:

$$L_H = \left( \frac{C}{P} \right)^{10/3} \times 500 \quad (3a)$$

**High Steady Load and Shock Load:** Bearing basic dynamic capacity,  $C$ , and basic static capacity,  $C_0$ , are determined through a consideration of entirely different factors. The criterion for dynamic capacity is the magnitude of the stressed volume of metal, and the probability that it will endure a given num-

ber of loading cycles. For static capacity the criterion is the influence of the elastic limit and rupture limit as manifested by the extent of permanent deformation that occurs. In view of the seemingly great difference in bases for consideration of dynamic and static capacities, it might be concluded that they bear no relation to one another. Such is not always the case when considering very high steady loads or shock loads present in a rotating bearing. The extent to which these loads approach (or exceed) the basic static capacity,  $C_0$ , will determine the validity of the use of the life formula. This relation may be expressed more explicitly by Equation 12. If

$$\frac{C_0}{f_0 P_0} \geq \frac{C/P}{(n/33\frac{1}{3})^{8/10}} \quad (12)$$

then the ordinary bearing life formula, Equation 1, may be used in determining bearing life. The value of the high radial or shock load is represented by  $P_0$ , and  $f_0$  is a safety factor selected from Table 3.

**Vibratory Loads:** A rotating bearing is sometimes subjected to a cyclic or vibratory load whose frequency in cycles per minute is large (at least one order of magnitude greater) with respect to bearing rotational speed in revolutions per minute. Under these conditions, a mean load, calculated over the vibratory cycle, is valid for the total cycles associated with the life of the bearing. Considering a cyclically varying load (sinusoidal, or nearly so), whose maximum amplitude  $P_v$ , is superimposed upon a steady radial load,  $P_s$ , the equivalent mean load,  $P$ , may be expressed in terms of either the steady load or the maximum value of the varying load. In particular, when  $P_s > P_v$  then  $P = K_s P_s$ , and when  $P_v > P_s$ , then  $P = K_v P_v$ , where  $K_s$  and  $K_v$  are factors selected from Table 4.

**Multiple-Bearing Applications:** The expected minimum life (10 per cent failure) of a complete bearing application when two or more bearings are mounted on the same support is often needed. This information is particularly helpful where fixed time-interval maintenance programs are followed and/or parts are periodically dismounted for replacement.

The minimum life of a complete bearing application is less than the lowest calculated minimum life of any bearing that is part of the application. This is due to the fact that the probability of survival of the whole application is equal to the product of the probabilities of survival of each bearing.

The life,  $L$ , which 90 per cent of a group of similar complete applications will have, is given by

$$\frac{1}{L} = \left[ \left( \frac{1}{L_1} \right)^e + \left( \frac{1}{L_2} \right)^e + \dots + \left( \frac{1}{L_n} \right)^e \right]^{1/e} \quad (13)$$

where  $L_1, L_2, \dots, L_n$  are respective minimum lives of each bearing in the application, and  $e$  (exponent for life dispersion) equals 1.11.

Table 3—Shock Service Factors

Service	$f_0$
Occasional high steady load, no shock load	0.5
Continuous high steady load, no shock load	1.0
Maximum shock loads and smooth subsequent operation required	2.0

Table 4—Vibratory Load Factors

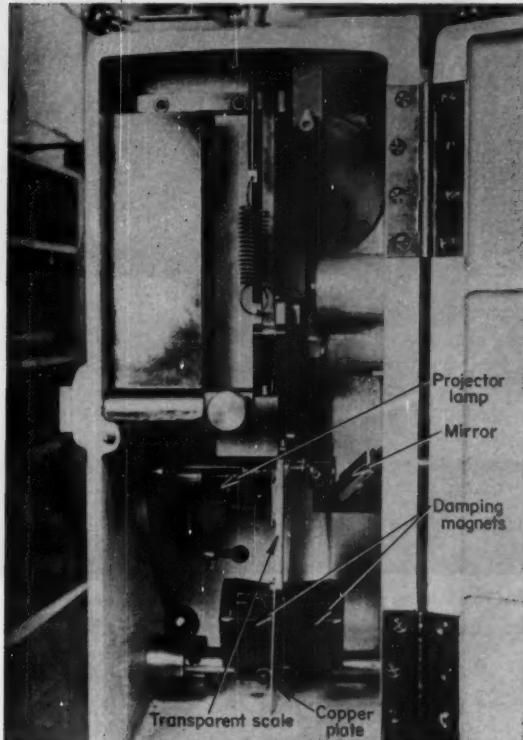
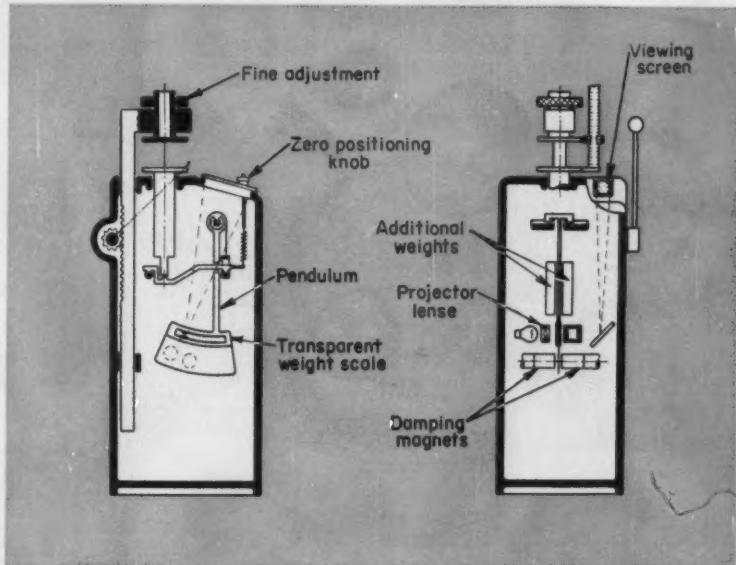
For $P_v > P_s$		For $P_s > P_v$	
$P_v/P_s$	$K_s$	$P_s/P_v$	$K_v$
0.00	1.000	0.00	0.752
0.20	1.020	0.20	0.794
0.40	1.074	0.40	0.902
0.60	1.155	0.60	1.042
0.80	1.251	0.80	1.197
1.00	1.357	1.00	1.357

Linear interpolation may be used without serious error.

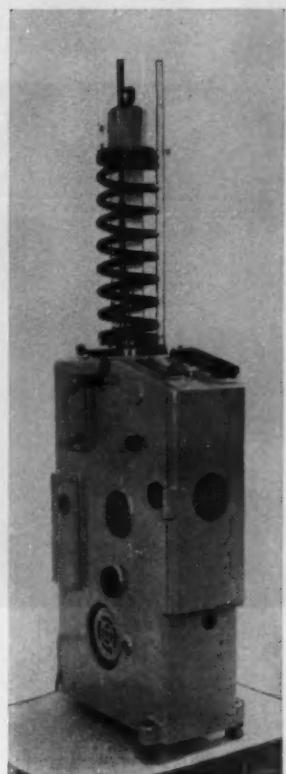
## Pendulum Replaces Accessory Weights For Wide Range of Loads in Spring Tester

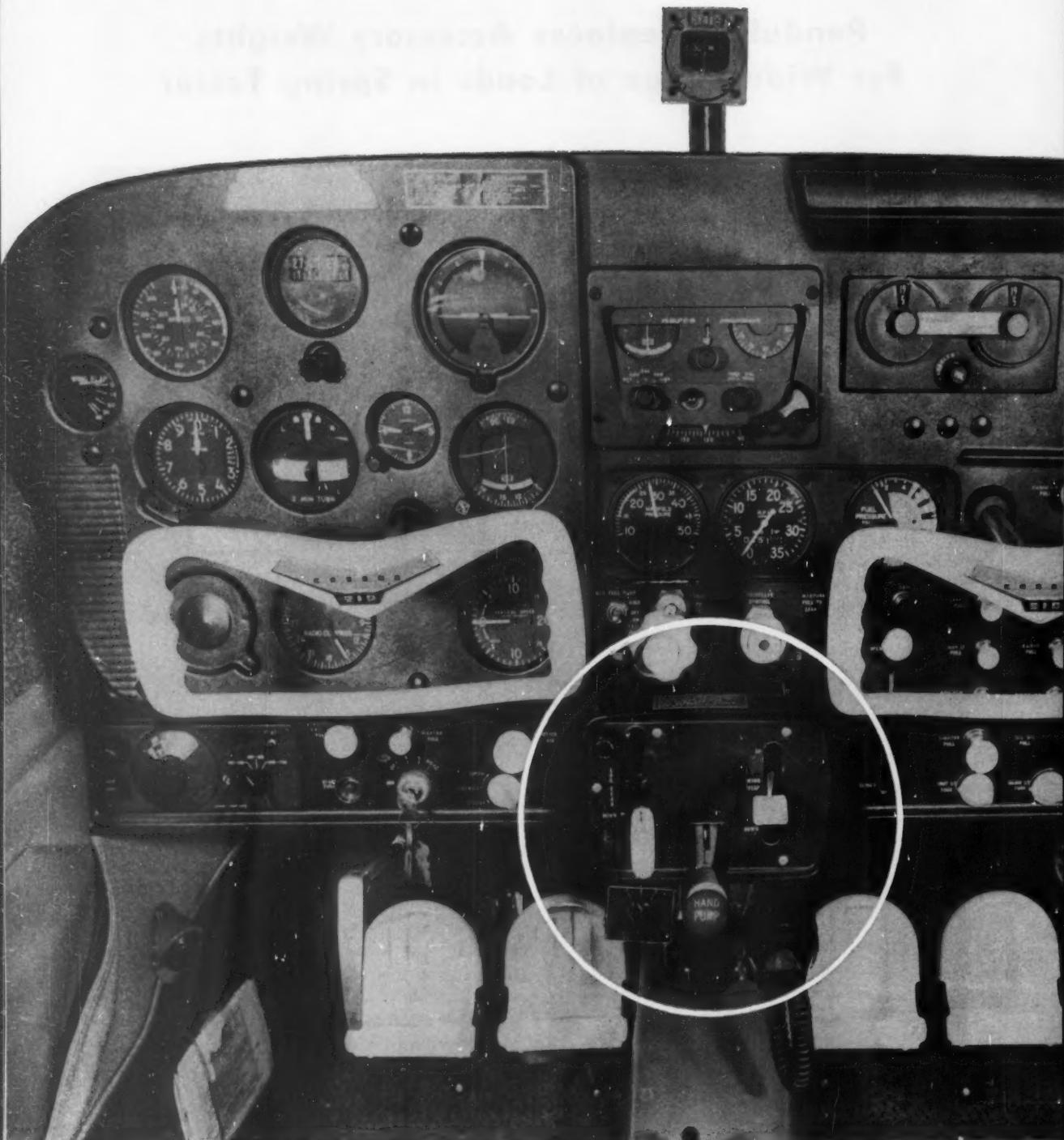
**HEAVILY WEIGHTED PENDULUM** in a new spring tester balances force of tested spring to locate a calibrated scale. Two adjustable pointers give limits of acceptability.

**POINTERS AND SCALE** are projected to a screen in the top of the housing for easy external reading. Copper plate at the bottom of the pendulum swings between magnet faces for eddy-current damping of spring oscillations.



**TYPICAL OPERATION** starts by setting desired spring height with size blocks. Pendulum is adjusted to apply desired force at this height. Slide pointers are set for acceptable limits, and the machine is ready to test a series of springs. A change of mounting makes the machine equally useful for testing tension springs. Capacity is in two easily interchangeable ranges:  $\frac{1}{4}$  to 110 lb, or  $\frac{1}{4}$  to 550 lb. Tester is produced by the Carlson Co., Oceanside, N. Y.



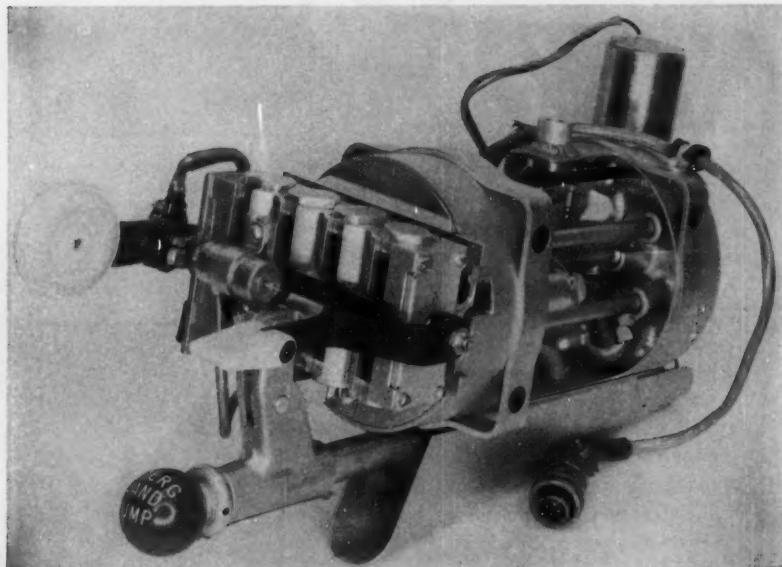


**POWER PACK** contains hydraulic reservoir, solenoid and priority valves, gear and flap controls, along with emergency hand pump.



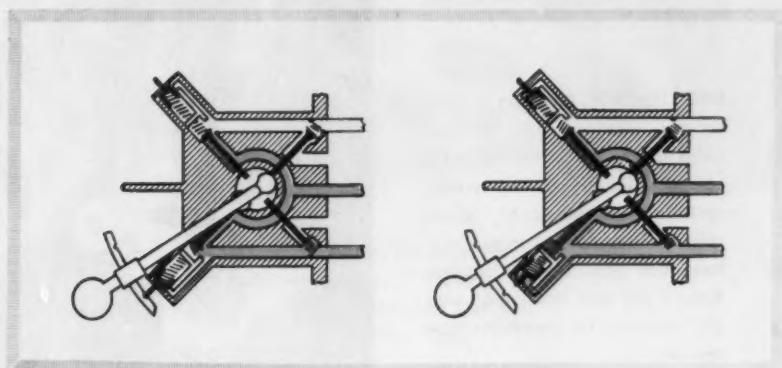
High-styled new high-wing using the controls package is the Cessna 210—first high-wing monoplane to have fully retractable landing gear (see MD, Nov. 26, 1959, p. 23).

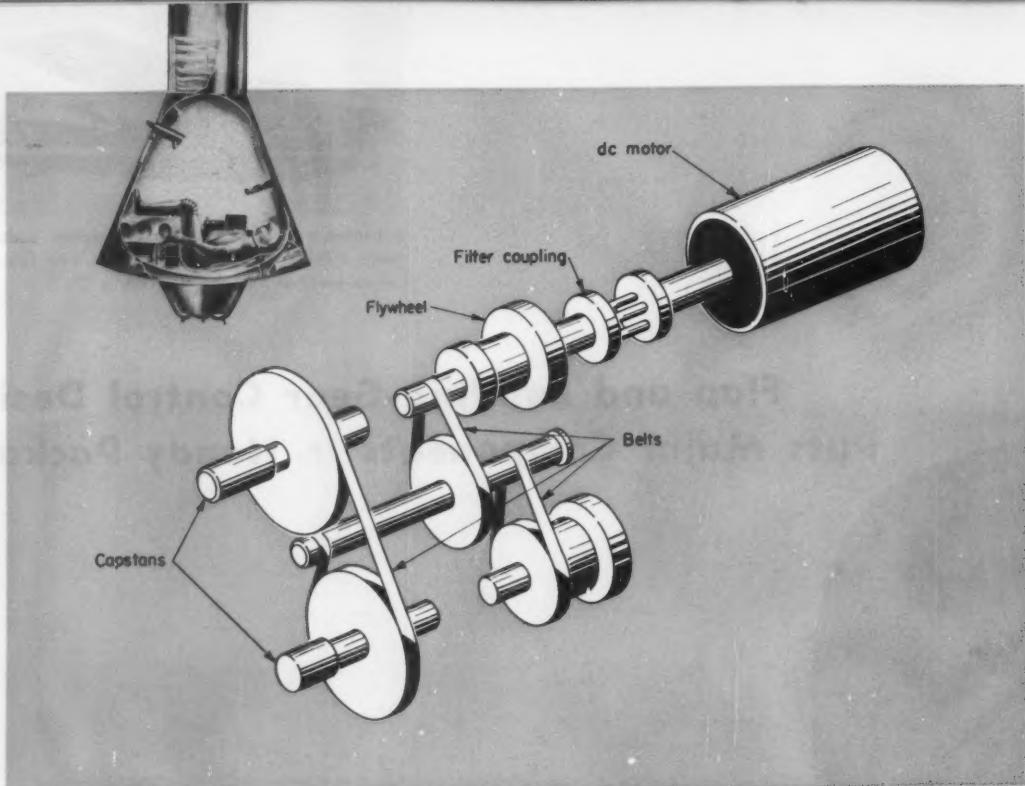
## Flap and Landing-Gear Control Design Puts Major Components in Handy Package



**STATIONARY DETENT** separates gear-up neutral from gear-down neutral—safety against dropping the plane on its belly after a successful landing.

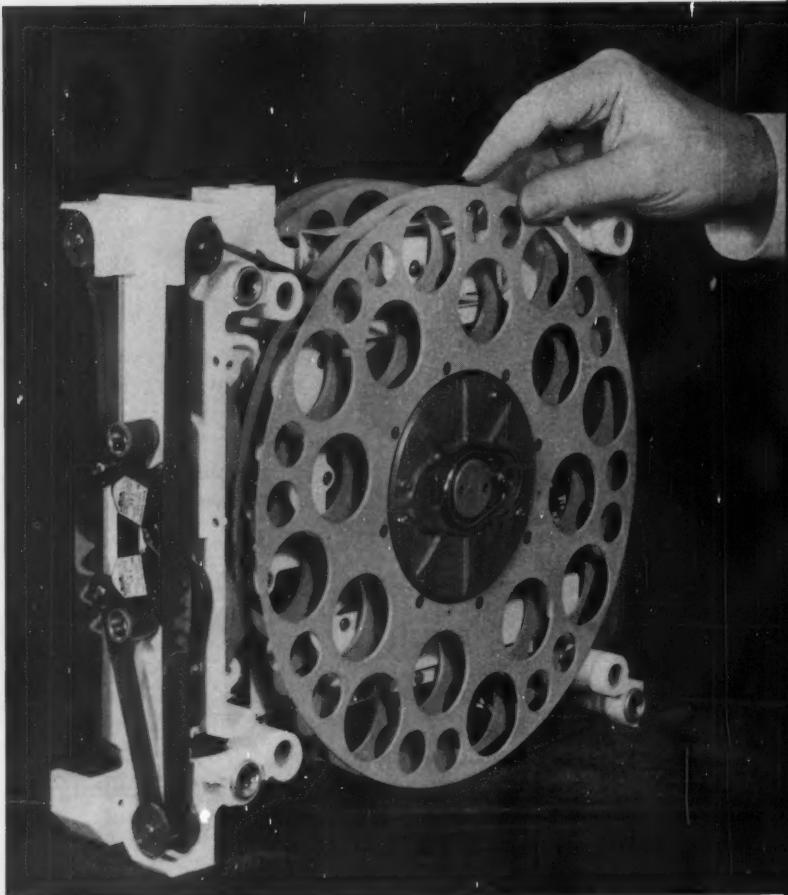
**GEAR-UP AND GEAR-DOWN DETENTS** are "kicked out" by surge of hydraulic pressure when gear has completed its motion. Handle snaps back to neutral.



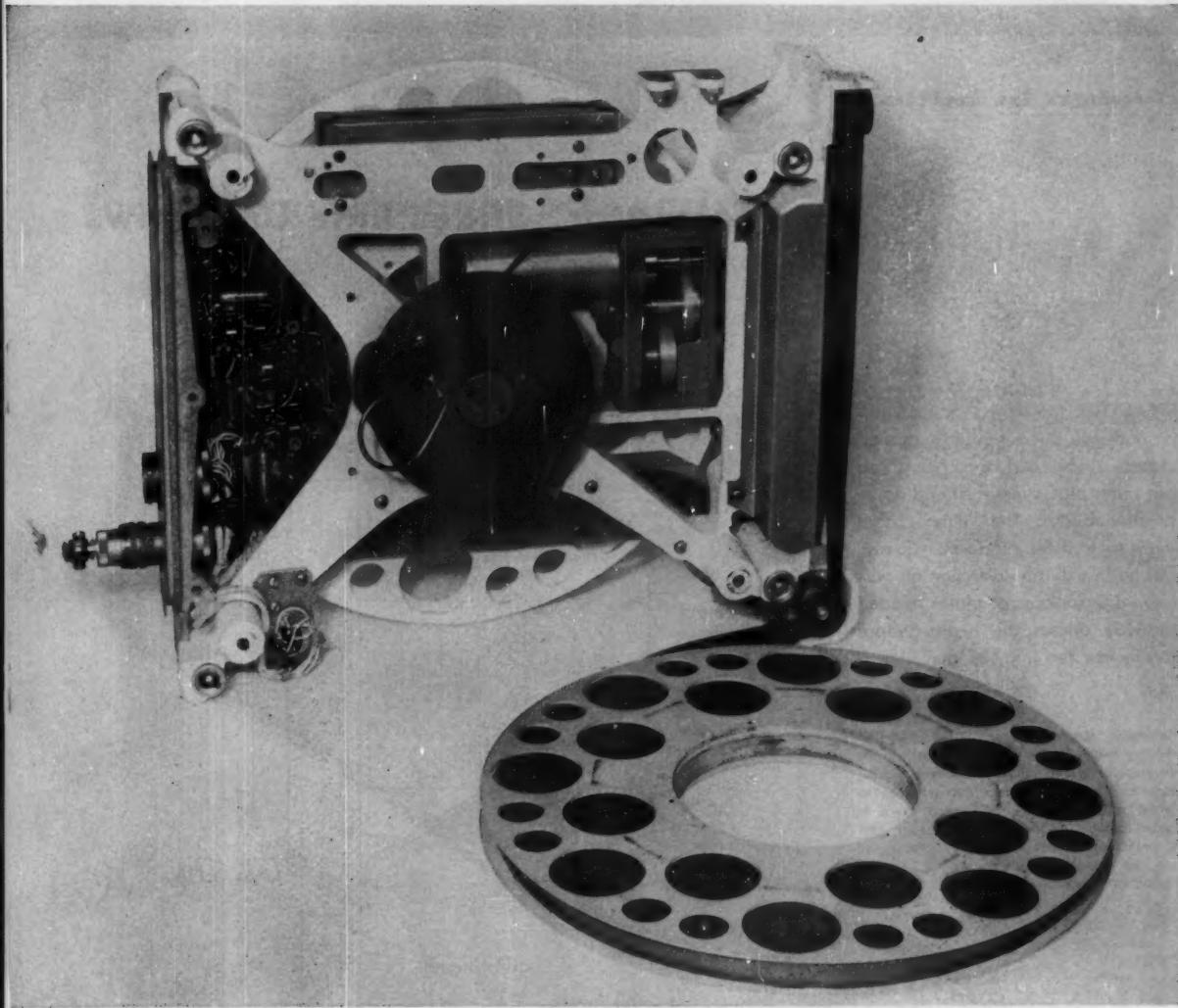


**BELTS MADE OF NYLON** impregnated with silicone rubber have been used instead of conventional speed-reducer components for eliminating backlash in Project Mercury's tape recorder. The belts do not generate offensive odors or noxious gas, nor absorb precious oxygen. They exhibit no stretch under the load requirements for the operation. The capstan transmission in which they are used reduces the speed of the 10,000-rpm dc motor by 1/158 to drive the tape at 1 $\frac{1}{8}$  ips. A small flywheel and a filter coupling smooth out slight irregularities in the motor speed. Tape speed can be changed to 15 ips by changing two belts and the takeup clutch.

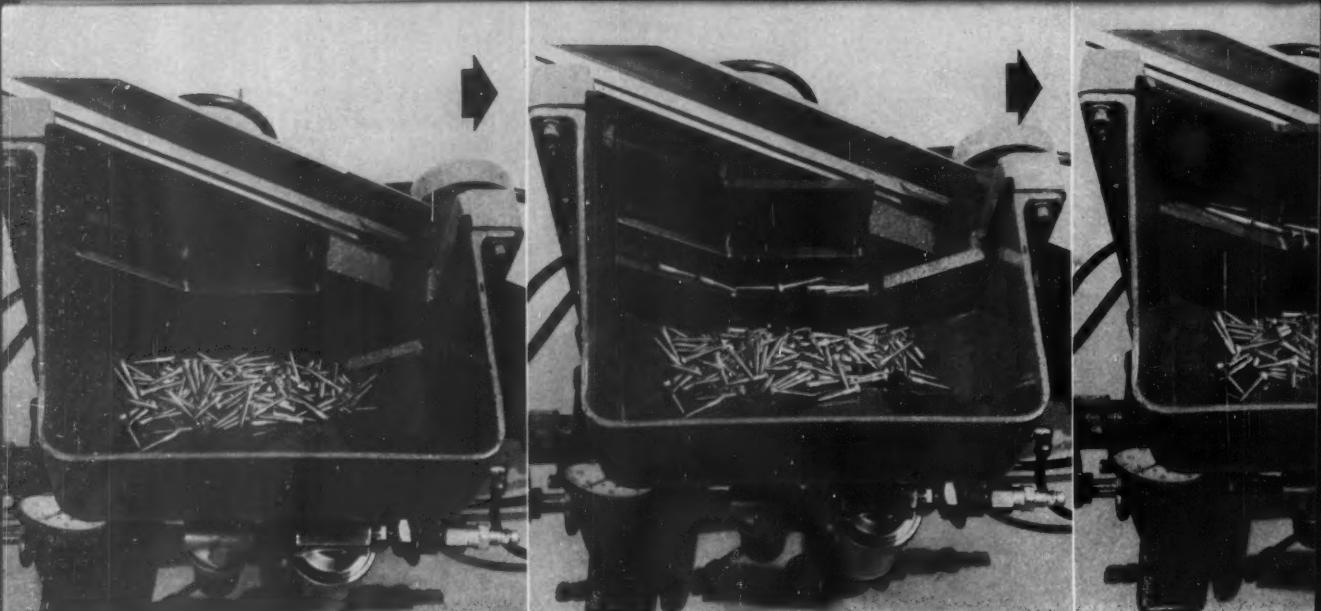
**BACK-TO-BACK** mounting of reels around other recorder components makes the 12-lb unit very compact. Double capstan system, replacing conventional pinch rollers, uses less energy; distorts tape less. Take-up capstan turns 1 per cent faster than supply capstan to maintain tape tension.



## **Belt Drive Eliminates Backlash In Satellite Tape Recorder**



**ELECTRONIC PACKAGE** located back of the belt-drive box is hidden by the tape reels. Hub houses reel-drive motor and friction clutch that adjusts reel speed as diameter of tape on reel changes. A hub adapter allows play back on standard machine. Recorder was built by Datalab Div., Consolidated Electrodynamics Corp., Pasadena, Calif.

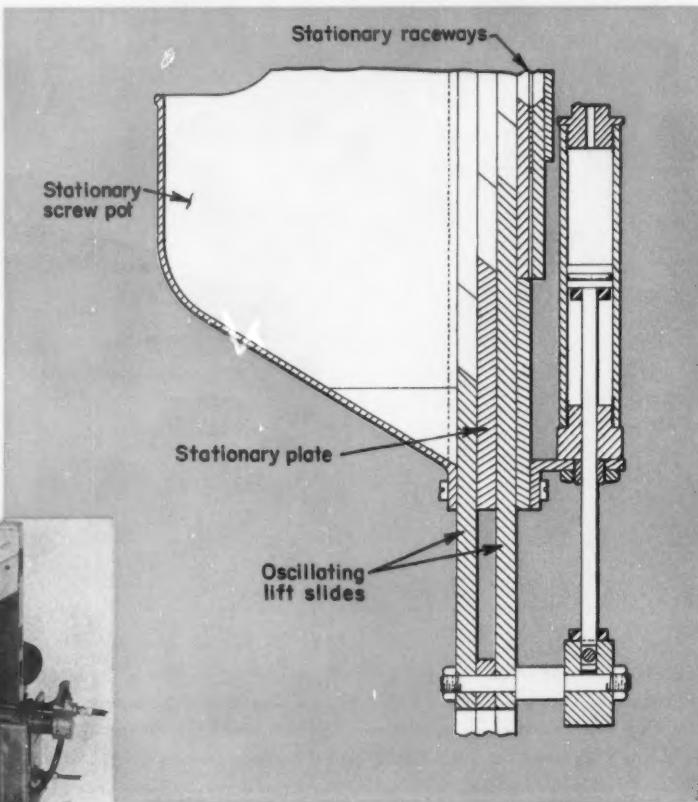
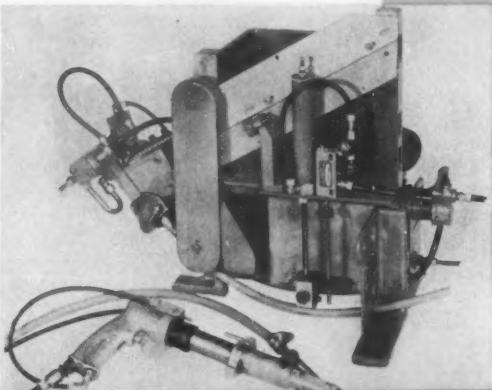


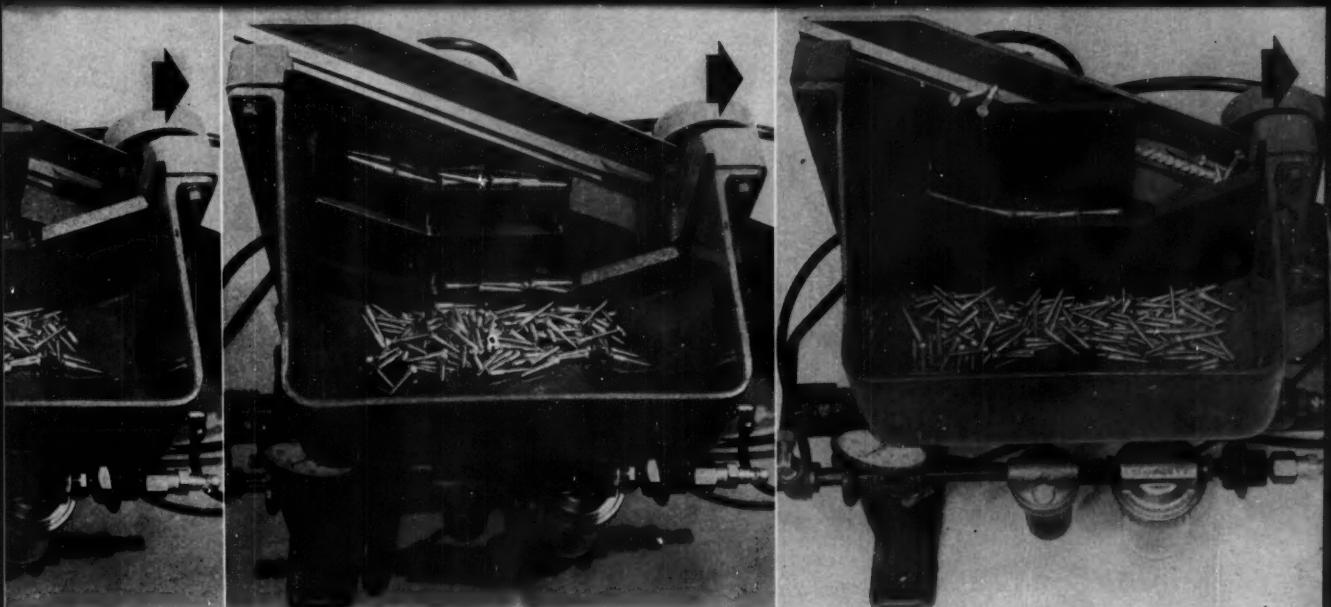
**design in action**

## "Escalator" Slides Line Up Screws

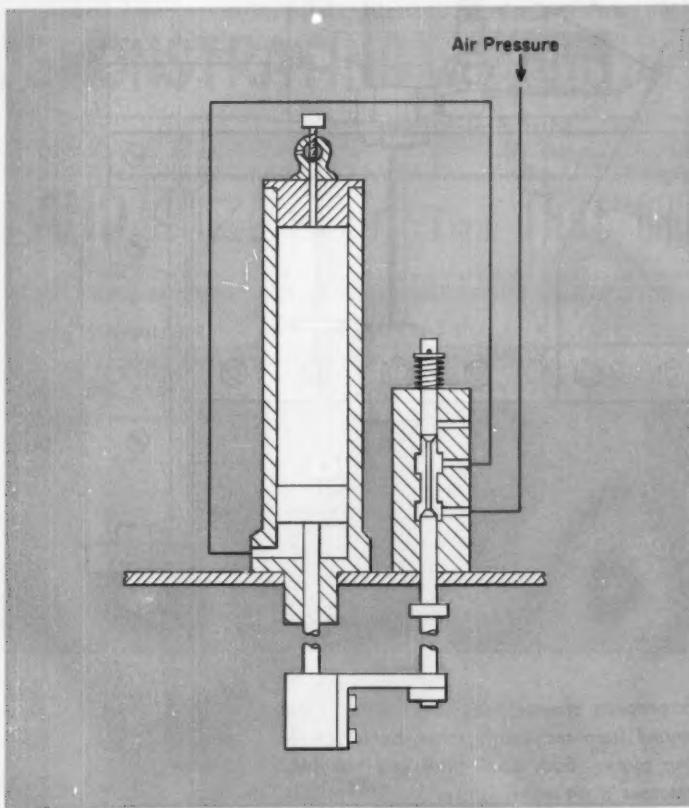
**ESCALATOR** for screws or fasteners is made of three similarly shaped plates sandwiched together. The two outer plates move up and down simultaneously. The inner plate forms a transfer platform. Screws can lie in only one direction on narrow edge surfaces of plates. Slotted raceway orients the heads before screws are fed into the gun.

Automatic screwdriver using the patented feeding mechanism is called Powasert by its developer, United Shoe Machinery Corp., Boston. The machine can also be used to orient other fasteners, and since there is some latitude in the size of fastener that a particular feeder can handle, one feeder can be used interchangeably on several fastening operations.



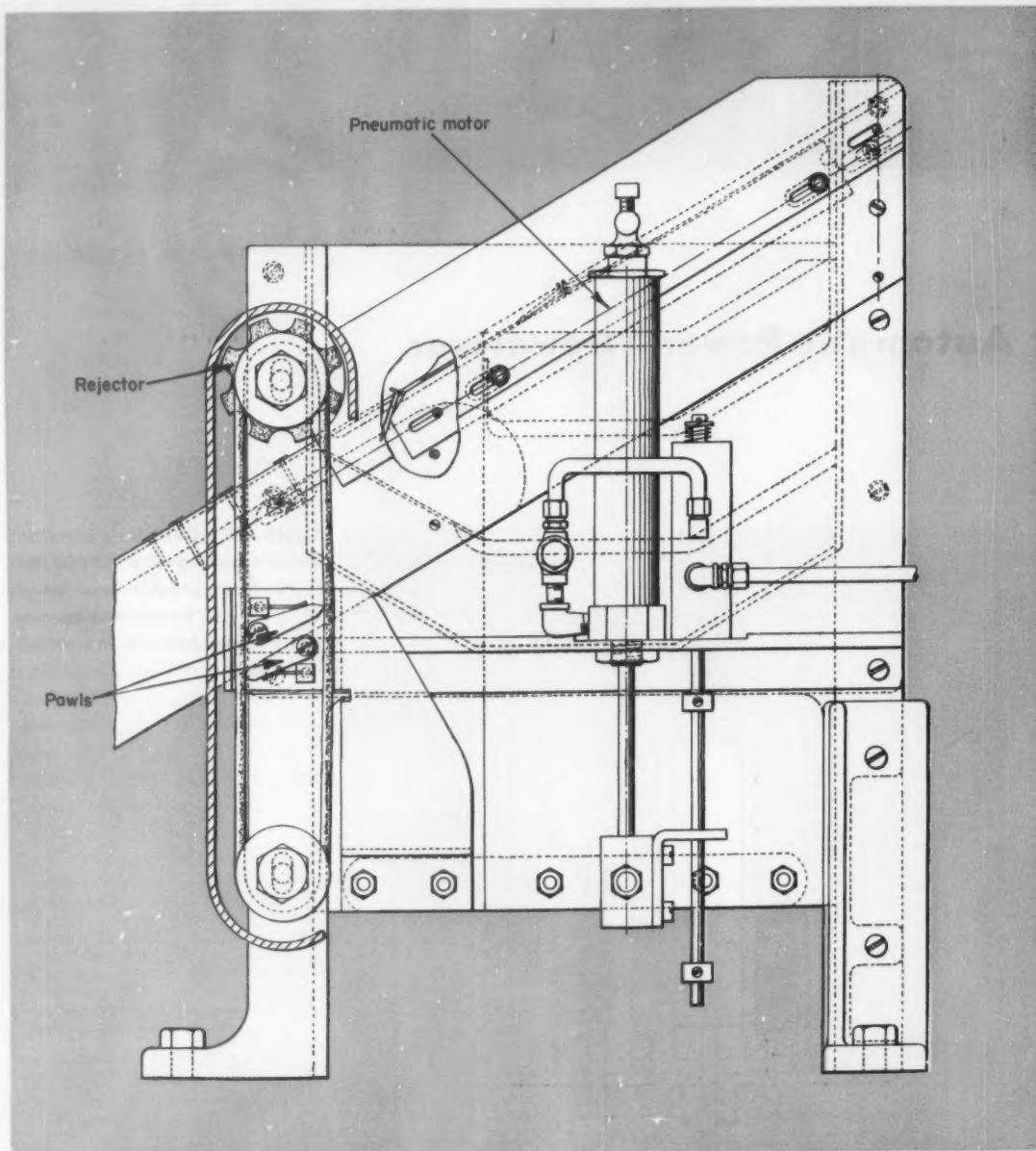


## For Automatic Power Screwdriver



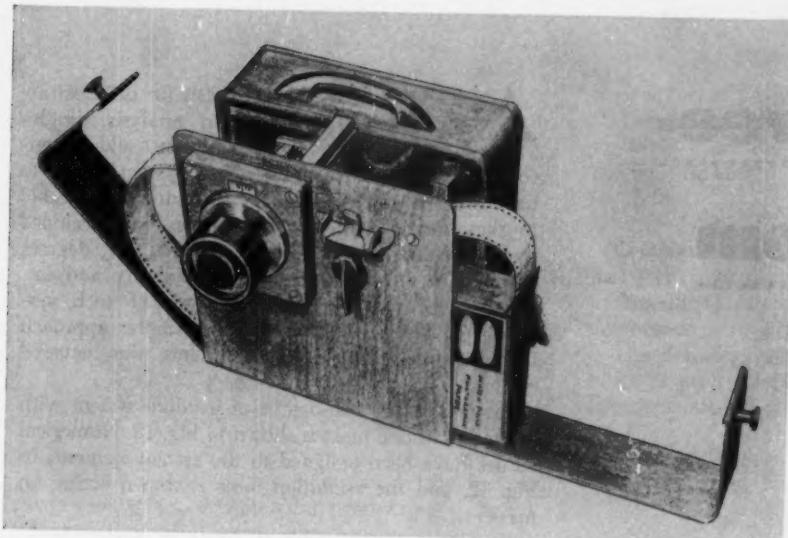
**SLIDES ARE MOVED** by a pneumatic motor consisting of a cylinder and a two-way control valve. Length of stroke can be adjusted by moving stop washers on the control-valve shaft.

**"Escalator" Slides Line Up Screws  
For Automatic Power Screwdriver**



**ROTARY REJECTOR** sweeps fasteners not properly oriented back into the bin. More or less constant rotary motion is obtained from reciprocal motion by a pair of opposed pawls fastened to the moving plate. Each pawl bites into the drive belt when moving in one direction—releases it on return stroke.

## Projection Slides Act as Type In Desk-Top Photo Typesetter

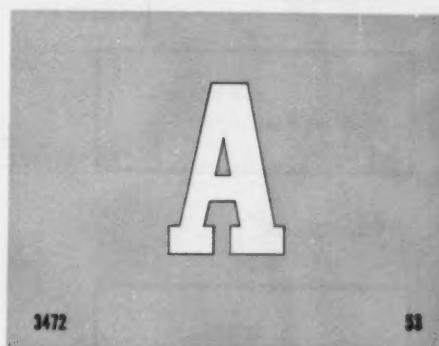


SPECIAL PRINTING PAPER, with movie-film-type sprocket holes, is loaded into a new photoprinter and threaded over a control sprocket. Projection-slide "type" is used to give the paper a timed exposure. Control knob is provided to space the characters and words by winding off a measured amount of paper. A special one-step developing bath demands a minimum of fussy techniques.

DEMONSTRATING A FEW of THE Styles

AND SIZES of Type That CAN be SET

TYPE IS AVAILABLE in a variety of styles and sizes from 6 to 72 points high. Figures on left of slide refer to style and size—on right, to suggested letterspacing. More or less spacing can be used to justify lines.



DESK-TOP MODEL, 8 by 8½ by 4½ in., is called Fotorex. It's a product of Electro-Rex Corp. of America, New York.

# Two-Degree-of-Freedom Systems

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ALTHOUGH useful as a basis for demonstrating concepts of vibration analysis, single-degree-of-freedom systems are seldom encountered in practice. The actual system is apt to have many degrees of freedom. Procedures applicable to these more complex systems may be developed with reference to a system having two degrees of freedom. Application of basic mobility and impedance techniques<sup>1</sup> to the analysis of such systems will be demonstrated here. A similar approach for single-degree-of-freedom systems was covered earlier.<sup>2</sup>

An undamped two-degree-of-freedom system with excitation at one mass is shown in Fig. 12. Numerical values have been assigned to the system elements in Fig. 12, and the excitation force is shown acting on mass  $m_1$ .

**Classical Method:** Basic relationships are provided by the classical method of writing differential equations. The natural circular frequencies and the amplitudes of masses  $m_1$  and  $m_2$  are obtained from

$$\omega_n^2 = \frac{k_1 + k_2}{2m_1} + \frac{k_2}{2m_2} \pm \left[ \left( \frac{k_1 + k_2}{2m_1} + \frac{k_2}{2m_2} \right)^2 - \frac{k_1 k_2}{m_1 m_2} \right]^{\frac{1}{2}} \quad (36)$$

$$x_{1o} = \frac{\frac{F_o}{k_1} \left( 1 - \frac{m_2 \omega^2}{k_2} \right)}{\left( 1 - \frac{m_2 \omega^2}{k_2} \right) \left( 1 + \frac{k_2}{k_1} - \frac{m_1 \omega^2}{k_1} \right) - \frac{k_2}{k_1}} \quad (37)$$

$$x_{2o} = \frac{\frac{F_o}{k_1}}{\left( 1 - \frac{m_2 \omega^2}{k_2} \right) \left( 1 + \frac{k_2}{k_1} - \frac{m_1 \omega^2}{k_1} \right) - \frac{k_2}{k_1}} \quad (38)$$

Substituting the numerical values, Fig. 12, into Equation 36 gives

$$\omega_n^2 = \frac{(5 + 10)10^6}{2(0.1)} + \frac{10(10^6)}{2(1)} \pm \left[ (80)^2 10^{12} - \frac{5(10)(10^{12})}{1(0.1)} \right]^{\frac{1}{2}}$$

or, with the lower value of natural frequency desig-

<sup>1</sup>References are tabulated at end of article.

# Simplified Vibration Analysis 3

nated by subscript I and the higher value by II,

$$\omega_{nI} = 1783 \text{ rad per sec}$$

$$\omega_{nII} = 12500 \text{ rad per sec}$$

For the amplitudes, from Equations 37 and 38,

$$x_{1o} = \frac{\frac{10}{5(10^6)} \left[ 1 - \frac{\omega^2}{10(10^6)} \right]}{\left[ 1 - \frac{\omega^2}{10(10^6)} \right] \left[ 1 + 2 - \frac{0.1\omega^2}{5(10^6)} \right] - 2} \quad (37a)$$

$$x_{2o} = \frac{\frac{10}{5(10^6)}}{[1 - 0.1(10^{-6})\omega^2][1 + 2 - 0.02(10^{-6})\omega^2] - 2} \quad (38a)$$

For this analysis, the system can be divided into two subsystems, designated by subscripts 1 and 2. This method of attack is more convenient and helps clarify and illustrate certain points as the work progresses. Thus, the natural frequencies of the subsystems are

$$\omega_{n1} = \left( \frac{k_1}{m_1} \right)^{1/2} = \left[ \frac{5(10^6)}{0.1} \right]^{1/2} = 7070 \text{ rad per sec}$$

$$\omega_{n2} = \left( \frac{k_2}{m_2} \right)^{1/2} = \left[ \frac{10(10^6)}{1} \right]^{1/2} = 3162 \text{ rad per sec}$$

Values of displacement amplitudes  $x_{1o}$  and  $x_{2o}$  for several assumed frequencies,  $\omega$ , have been calculated with Equations 37a and 38a and are listed in Table 4. Also, with both masses vibrating at impressed frequency  $\omega$ , values of the velocity amplitudes,  $v_{1o}$  and  $v_{2o}$ , listed in Table 4 were obtained from

$$v_{1o} = x_{1o} \omega$$

$$v_{2o} = x_{2o} \omega$$

Since the system has no damping, phase angle  $\psi$  is either +90 or -90 deg ( $\phi = 0$  or 180 deg) as indicated by the positive or negative velocities.

Two mobilities are evident in this system. One is the driving-point mobility,  $M_{11}$ , which is the response of mass  $m_1$  resulting from the impressed force  $F_o$  acting on mass  $m_1$ . The other is the transfer mobility,  $M_{21}$ , which is the response of mass  $m_2$  resulting from the impressed force  $F_o$  acting on mass  $m_1$ .

It can be proved<sup>3</sup> that the reciprocity principle holds for mobilities  $M_{12}$  and  $M_{21}$ . That is, the response of mass  $m_1$  resulting from a unit impressed force acting on mass  $m_2$  equals the response of mass  $m_2$  resulting from a unit impressed force acting on

mass  $m_1$  or,  $M_{12} = M_{21}$ .

The driving-point and transfer velocity mobilities in Table 4 are found by dividing velocities  $v_{1o}$  and  $v_{2o}$  by the maximum value of impressed force  $F_o$ , or, 10 lb.

**Component-Mobility Method:** For this method, the first step is to draw the schematic diagram shown in Fig. 13. This schematic, for Fig. 12, is drawn in accordance with principles previously outlined.<sup>1</sup>

The defining equations which represent the mobility of each component, including numerical substitutions, are

$$M_{Vm1} = -\frac{j}{m_1 \omega} = -\frac{10j}{\omega}$$

$$M_{Vm2} = -\frac{j}{m_2 \omega} = -\frac{j}{\omega}$$

$$M_{Vki} = \frac{j\omega}{k_1} = 0.2(10^{-6})j\omega$$

$$M_{Vkj} = \frac{j\omega}{k_2} = 0.1(10^{-6})j\omega$$

These mobilities are the straight lines in Fig. 14.

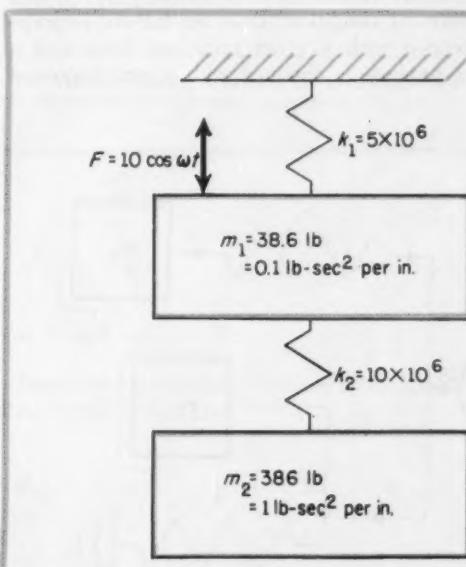


Fig. 12—Conventional representation of mechanical system having two degrees of freedom.

## Two-Degree-of-Freedom Systems

From Fig. 13, note that  $M_{Vm2}$  and  $M_{Vk2}$  act in series. Hence, from Equation 18,<sup>1</sup>

$$M_{V2} = M_{Vm2} + M_{Vk2} \quad (39)$$

All points attached to mass  $m_1$  have a common velocity and therefore act in parallel. Consequently, the combined driving-point velocity mobility,  $M_{V11}$ , according to Equations 19 and 20,<sup>1</sup> is

$$\begin{aligned} M_{V11} &= \frac{1}{\frac{1}{M_{Vm1}} + \frac{1}{M_{Vk1}} + \frac{1}{M_{V2}}} \\ &= \frac{1}{Z_{Vm1} + Z_{Vk1} + Z_{V2}} \end{aligned} \quad (40)$$

To obtain the transfer velocity mobility,  $M_{V21}$ , first note that the force acting on branch 2 in Fig. 13 is  $F_2$ , where

$$F_2 = \left( \frac{F_2}{F_o} \right) F_o = \left( \frac{Z_{V2}}{Z_{V11}} \right) F_o \quad (41)$$

Then,

$$v_{2o} = M_{Vm2} F_2 = \frac{M_{Vm2} Z_{V2} F_o}{Z_{V11}} \quad (42)$$

Therefore,  $M_{V21}$ , the velocity of mass  $m_2$  caused by impressed force  $F_o$  applied at mass  $m_1$ , is

$$M_{V21} = \frac{v_{2o}}{F_o} = \frac{M_{Vm2} Z_{V2}}{Z_{V11}} = \frac{M_{Vm2} M_{V11}}{M_{V2}} \quad (43)$$

Values of  $M_{V11}$  and  $M_{V21}$  are listed in Table 4 and plotted in Fig. 14.

**Response Curves:** At this point, several interesting and important features of Fig. 14 deserve comment. Note that an infinite value of mobility corresponds to a resonant condition, since an infinite response is associated with a given impressed force and a definite response is obtained with a zero impressed

force. For a corresponding situation on an impedance plot, the impedance becomes zero at resonance. In Fig. 14, two resonant conditions occur at the system natural frequencies of 1783 and 12,500 rad per sec.

When the impressed frequency is the same as the natural frequency of  $k_2$  and  $m_2$ , or at  $\omega_{n2} = 3162$  rad per sec in Fig. 14,  $M_{V11}$  is zero. This condition indicates an antiresonant or nodal condition for mass  $m_1$ . Frequency  $\omega_{n2}$  corresponds to the intersection of the  $M_{Vm2}$  and  $M_{Vk2}$  lines, thus indicating a natural frequency for the lower mass and spring of Fig. 12, or for branch 2 of the schematic diagram in Fig. 13.

When the impressed frequency equals the natural frequency of the upper mass and spring in Fig. 12, or at  $\omega_{n1} = 7070$  rad per sec in Fig. 14, transfer mobility  $M_{V21}$  has a minimum value. The intersection of lines  $M_{Vk1}$  and  $M_{Vm1}$  at this frequency indicates a natural frequency of the upper mass and spring.

Between frequencies  $\omega_{n2}$  and  $\omega_{n1}$  (3162 and 7070 rad per sec, respectively) the values of  $M_{V21}$  are approximately equal to  $M_{Vm2}$  in Fig. 14. This condition indicates that the motion or velocity of mass  $m_2$  is primarily controlled by the size of  $m_2$  in this frequency range.

For low impressed frequencies, the controlling component for both  $M_{V11}$  and  $M_{V21}$  is spring  $k_1$  as shown by the curves becoming asymptotic to the  $M_{Vk1}$  line in Fig. 14. Thus, at low frequencies, spring  $k_1$  largely controls the motion. At high impressed

### Nomenclature

$F$	= Force, lb
$i$	= Number of mode shape
$j$	= Imaginary operator
$= (-1)^{\frac{j}{2}}$	
$k$	= Spring gradient or rate, lb per in.
$M$	= Mobility
$M_V$	= Velocity mobility, in. per lb-sec
$m$	= Mass, lb-sec <sup>2</sup> per in.
$Q$	= Amplification factor at resonance
$t$	= Time, sec
$v$	= Velocity, in. per sec
$x$	= Linear displacement, in.
$\dot{x}$	= Linear velocity, in. per sec
$Z_v$	= Velocity impedance, lb-sec per in.
$\beta$	= Ratio of impressed to natural frequency
$\psi$	= Phase angle between force and velocity vectors, deg or rad
$\omega$	= Circular or angular frequency, rad per sec

#### Subscripts

$i$	= Effective; mode number
$k$	= Spring element
$m$	= Mass
$n$	= Natural or resonant
$o$	= Amplitude or vector length; characteristic
$s$	= Spring
$I, II$	= Mode number

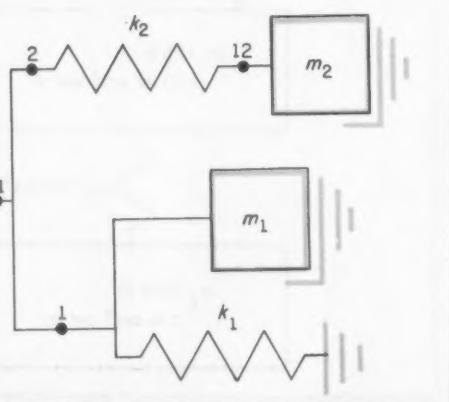


Fig. 13—Schematic mobility diagram for mechanical system in Fig. 12.

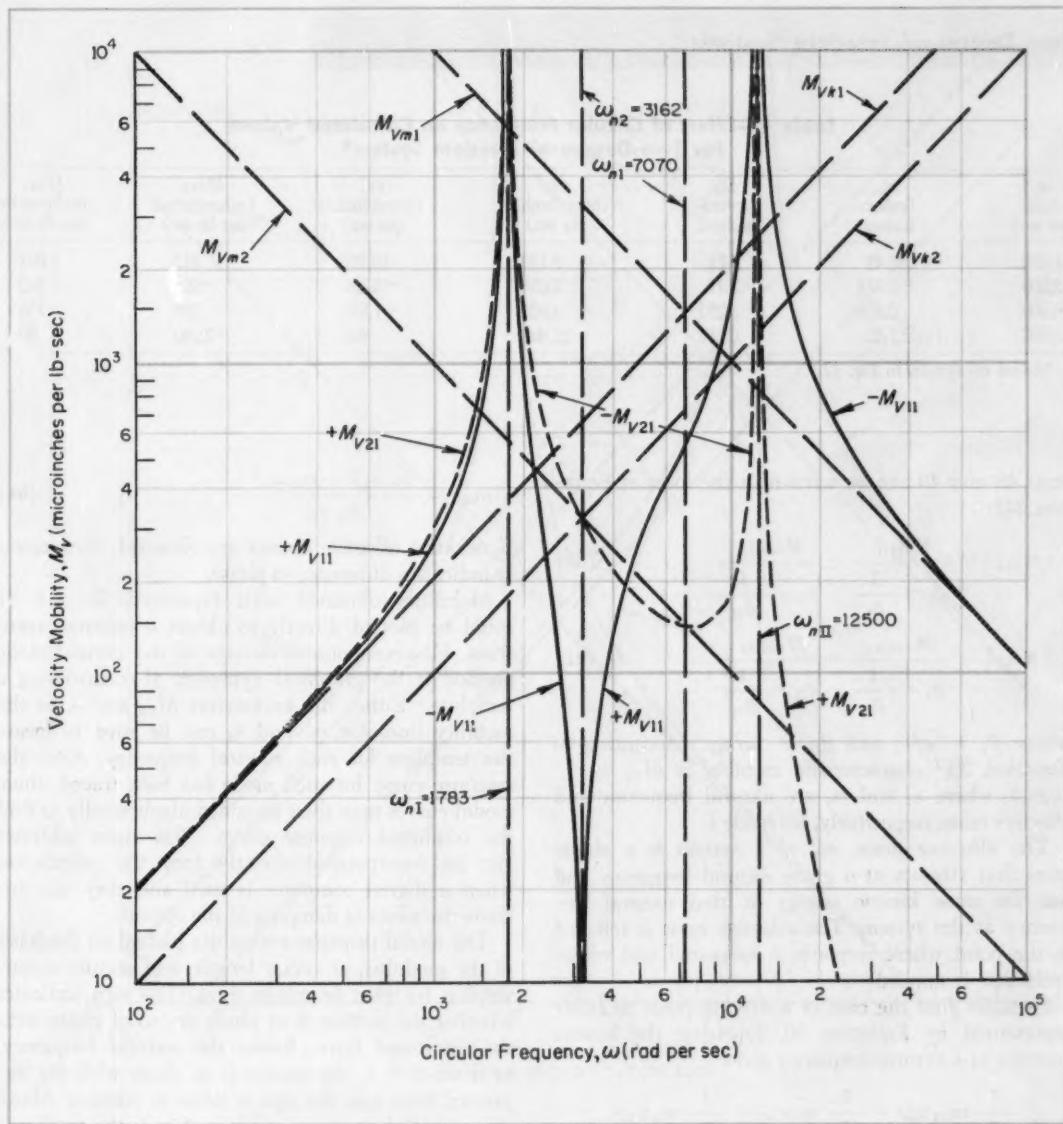


Fig. 14—Velocity-mobility spectrum for two-degree-of-freedom system represented by schematic diagram in Fig. 13.

frequencies, the motion of mass  $m_1$  is principally controlled by its own mass as shown by the  $M_{V11}$  curve being asymptotic to the  $M_{Vm1}$  line.

**Normal-Mode Mobility Method:** A two-degree-of-freedom system has two natural frequencies or normal modes of vibration. Associated with each natural frequency is a unique mode shape or amplitude ratio,  $x_{20}/x_{10}$ . Since motion at the natural frequency is harmonic, the mode shape or amplitude ratio is the same whether vibration is free or forced.

If the system is subjected to a forced harmonic vibration, motion of each mass is composed of the algebraic sum of the motions produced by each mode separately. Thus,

$$x_1 = x_{11} + x_{111} \quad (44)$$

$$x_2 = x_{21} + x_{211} \quad (45)$$

or,

$$\dot{x}_1 = \dot{x}_{11} + \dot{x}_{111} \quad (46)$$

$$\dot{x}_2 = \dot{x}_{21} + \dot{x}_{211} \quad (47)$$

Important relationships obtained by dividing Equations 46 and 47 by  $F_o$  are:

$$M_{V11} = \frac{\dot{x}_1}{F_o} = \frac{\dot{x}_{11}}{F_o} + \frac{\dot{x}_{111}}{F_o} = M_{V111} + M_{V1111} \quad (48)$$

$$M_{V21} = \frac{\dot{x}_2}{F_o} = \frac{\dot{x}_{21}}{F_o} + \frac{\dot{x}_{211}}{F_o} = M_{V211} + M_{V2111} \quad (49)$$

For a system having no damping ( $Q = \infty$ ), Equa-

## Two-Degree-of-Freedom Systems

**Table 4—Effect of Circular Frequency on Calculated Values  
For Two-Degree-of-Freedom System\***

$\omega$ (rad per sec)	$x_{1o}$ (micro-inches)	$x_{2o}$ (micro-inches)	$v_{1o}$ (microinches per sec)	$v_{2o}$ (microinches per sec)	$M_{V11}$ (microinches per lb-sec)	$M_{V21}$ (microinches per lb-sec)
1,500	5.43	7.01	8,150	10,510	815	1,051
2,500	-0.814	-2.17	-2,035	-5,420	-204	-542
6,000	0.655	-0.252	3,930	-1,510	393	-151
15,000	-1.42	0.066	-21,400	991	-2,140	99

\*Based on system in Fig. 12.

tions 48 and 49 can be written in the form of Equation 34<sup>2</sup>:

$$|M_{V11}| = \frac{M_{V0111}}{\beta_1 - \frac{1}{\beta_1}} + \frac{M_{V01111}}{\beta_{II} - \frac{1}{\beta_{II}}} \quad (50)$$

$$|M_{V21}| = \frac{M_{V0211}}{\beta_1 - \frac{1}{\beta_1}} + \frac{M_{V02111}}{\beta_{II} - \frac{1}{\beta_{II}}} \quad (51)$$

where  $\beta_1 = \omega/\omega_1$  and  $\beta_{II} = \omega/\omega_{II}$ . According to Equation 29,<sup>2</sup> characteristic mobility is  $M_{V0} = 1/(\omega_i m_i)$ , where  $\omega_i$  and  $m_i$  are natural frequency and effective mass, respectively, for mode  $i$ .

The effective mass,  $m_i$ , of a system is a single mass that vibrates at a given natural frequency and has the same kinetic energy at that natural frequency as the system. The effective mass is referred to the point where response is measured and where excitation is applied.

Consider first the case of a driving-point mobility represented by Equation 50. Equating the kinetic energies at a natural frequency gives

$$\frac{1}{2} m_{i11} v_{1o}^2 = \frac{1}{2} m_1 v_{1o}^2 + \frac{1}{2} m_2 v_{2o}^2$$

or, since  $v_o = x_{o\omega}$ ,

$$m_{i11} = \frac{m_1 x_{1o}^2 + m_2 x_{2o}^2}{x_{1o}^2} \quad (52)$$

where values of  $x_o$  are amplitudes of the masses of the system at the natural frequency being considered. Also, values of  $x_o$  in Equation 52 have the same amplitude ratio for  $x_{2o}/x_{1o}$  that would be obtained if vibration were free. Hence, values of  $x_{1o}$  and  $x_{2o}$ , based on a free vibration, can be used to determine  $m_i$ .

In addition to effective mass, effective spring gradient  $k_i$  can also be found from  $\omega_i^2 = k_i/m_i$ , or,

$$k_i = m_i \omega_i^2 \quad (53)$$

For the transfer mobility of Equation 51, the effective mass must be referred to the transfer point, or the point of response. Thus,

$$\frac{1}{2} (m_{i21} v_{1o}^2) \frac{v_{2o}}{v_{1o}} = \frac{1}{2} m_1 v_{1o}^2 + \frac{1}{2} m_2 v_{2o}^2$$

Introducing the  $v_o = x_{o\omega}$  relationship gives

$$m_{i21} = \frac{m_1 x_{1o}^2 + m_2 x_{2o}^2}{x_{1o} x_{2o}} \quad (54)$$

If negative effective masses are obtained, they merely indicate a difference in phase.

Mobilities obtained with Equations 50 and 51 could be plotted directly to obtain a response spectrum. However, one advantage of the normal-mode method is the graphical approach of constructing a template.<sup>2</sup> Either the parameters  $M_{V0}$  and  $\omega_i$  or the mobility lines for  $m_i$  and  $k_i$  can be used to locate the template for each natural frequency. After the response curve for each mode has been traced, these modal curves may then be added algebraically to find the combined response curve. This curve addition can be incorporated directly into the calculation when a digital computer is used and may also include the effect of damping in the system.

The modal response curves are plotted on the basis of the modulus, or vector length, and require a convention for plus or minus signs. The sign indicates whether the motion is in phase or out of phase with the impressed force. Below the natural frequency, or when  $\beta < 1$ , the motion is in phase with the impressed force and the sign is taken as positive. Above the natural frequency, or when  $\beta > 1$ , the motion is out of phase and the sign is negative. Obviously, a negative effective mass or negative characteristic mobility will cause the signs to be reversed.

The graphical method will now be applied to the system in Fig. 12. With the classical method, two natural frequencies of the system were found at 1783 and 12,500 rad per sec. Corresponding amplitudes of free vibration,  $x_{1o}$  and  $x_{2o}$ , based on an amplitude of +1 for mass  $m_2$ , can be found from Equations 37 and 38. These values are listed in Table 5 for the system under consideration, Fig. 12.

First, consider response at mass  $m_1$ , which is the driving-point mobility,  $M_{V11}$ . The effective masses,

**Table 5—Frequency-Amplitude Relationships  
for Two-Mass Vibrating System\***

Mode	$\omega$ (rad per sec)	$x_{1o}$	$x_{2o}$
I	1,783	+0.68	+1
II	12,500	-14.71	+1

\*Based on system in Fig. 12.

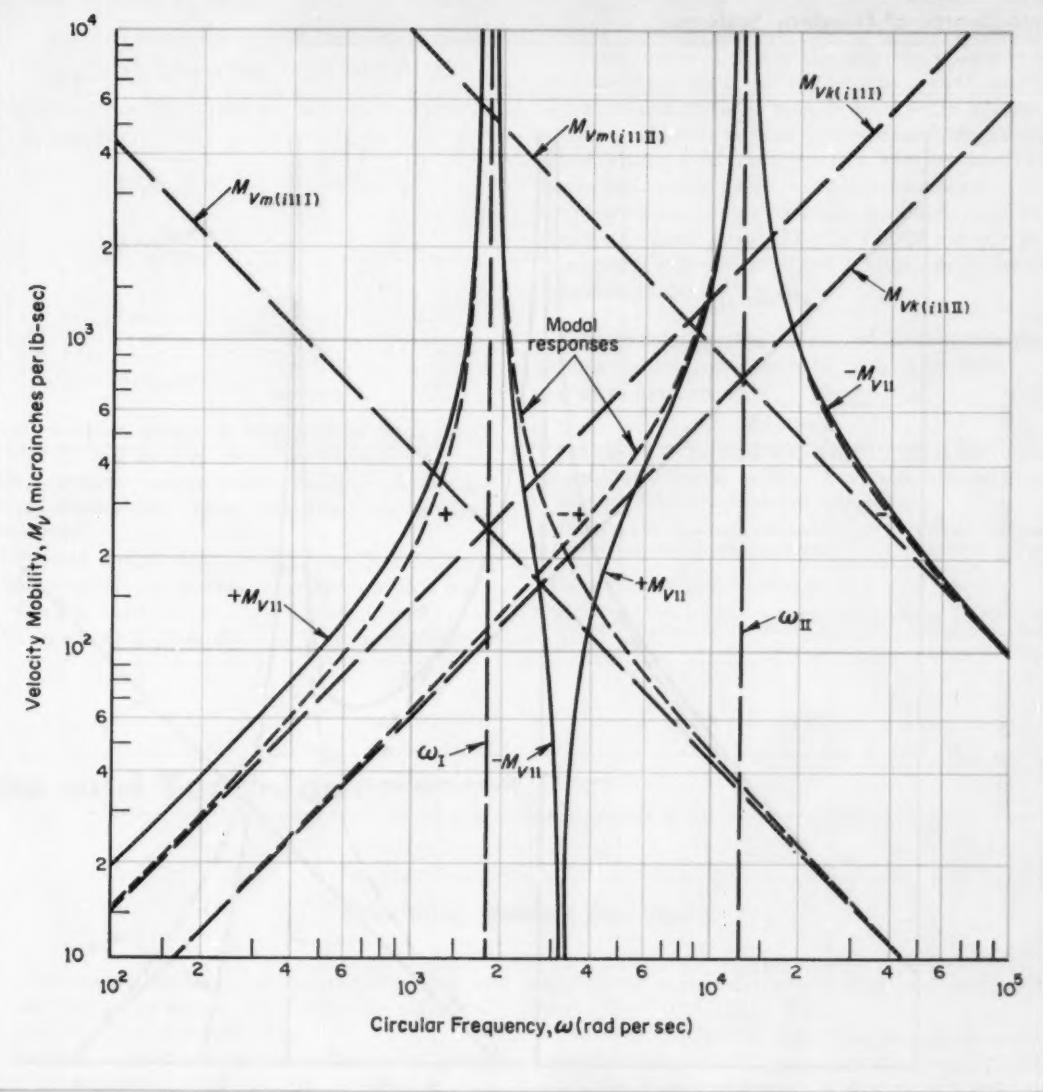


Fig. 15—Driving-point velocity-mobility spectrum for normal-mode mobility method of analyzing the system shown in Fig. 12.

$m_{i11}$ , may be found by substituting the values from Table 5 into Equation 52:

$$m_{i11} = \frac{0.1(+0.68)^2 + 1(+1)^2}{(+0.68)^2} = 2.253$$

$$m_{i111} = \frac{0.1(-14.71)^2 + 1(+1)^2}{(-14.71)^2} = 0.1047$$

Corresponding values of  $M_{V_0} = 1/(m_{i\omega_i})$ , from Equation 29,<sup>2</sup> are:

$$M_{V_0111} = \frac{1}{2.253(1783)} = 249(10^{-6})$$

$$M_{V_01111} = \frac{1}{0.1047(12500)} = 765(10^{-6})$$

These values of  $M_{V_0}$  may be inserted in Equation 50 to find points for the  $M_{V11}$  curve. The results will, of course, check the values which were found by the component-mobility method and plotted in Fig. 14.

An alternate and quicker method of obtaining the curves in Fig. 14 is to construct a template of celluloid or thin plastic based on values of the denominators of Equation 50. The template is then located on lines representing natural frequency and the spring and mass velocity mobilities.

Effective spring gradients from Equation 53 are:

$$k_{i111} = 2.253(1783)^2 = 7.15(10^6) \text{ lb per in.}$$

$$k_{i1111} = 0.1047(12500)^2 = 16.37(10^6) \text{ lb per in.}$$

Velocity mobilities for effective masses and springs

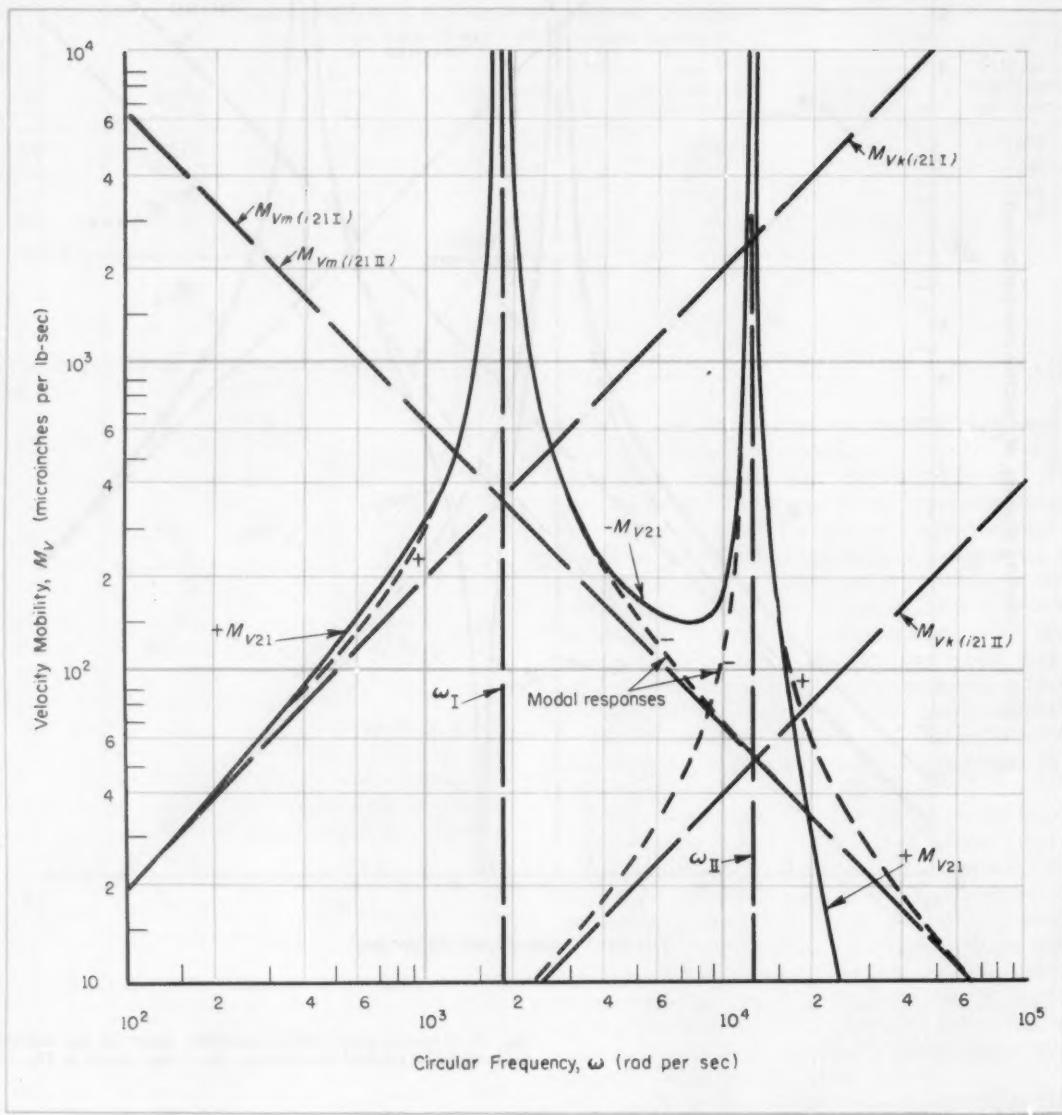


Fig. 16—Transfer velocity-mobility spectrum for normal-mode mobility method of analyzing the system shown in Fig. 12.

can now be determined:

$$M_{Vm(111I)} = -\frac{j}{2.253 \omega}$$

$$M_{Vm(111II)} = -\frac{j}{0.1047 \omega}$$

$$M_{Vk(111I)} = -\frac{j \omega}{7.15 (10^6)}$$

$$M_{Vk(111II)} = -\frac{j \omega}{16.37 (10^6)}$$

These equations locate the velocity mobility lines on log-log paper as shown in Fig. 15. The intersections

of these lines locate the template and the modal curves (short dash). Adding these curves algebraically gives the combined curve (solid) for driving-point mobility  $M_{V11}$ , Fig. 15. This curve, of course, checks the  $M_{V11}$  curve of Fig. 14.

The process for obtaining the transfer-mobility curve of Fig. 16 is similar to that just described. Effective masses, from Equation 54, are:

$$m_{i211} = \frac{0.1(+0.68)^2 + 1(+1)^2}{(+1)(+0.68)} = 1.535$$

$$m_{i211II} = \frac{0.1(-14.71)^2 + 1(+1)^2}{(+1)(-14.71)} = -1.54$$

and, from Equation 53, effective spring gradients are:

$$k_{i21I} = 1.535(1783)^2 = 4.89(10^6)$$

$$k_{i21II} = (-1.54)(12500)^2 = -241(10^6)$$

Mobility equations based on the effective masses and springs are

$$M_{Vm(i21I)} = -\frac{j}{1.535 \omega}$$

$$M_{Vm(i21II)} = -\frac{j}{1.54 \omega}$$

$$M_{Vh(i21I)} = -\frac{j \omega}{4.89(10^6)}$$

$$M_{Vh(i21II)} = -\frac{j \omega}{241(10^6)}$$

These mobilities, plotted as straight lines (long dash) on Fig. 16, are used to locate the template for the modal response (short dash). Adding the modal curves algebraically gives the combined-mobility curve (solid).

As before, values of  $M_{V_0}$  could have been inserted in Equation 51 to determine points on the  $M_{V21}$  curve in Fig. 14 or 16.

An interesting byproduct of the normal-mode

method of plotting response curves is that a comparison of modal response curves with the resultant combined curve discloses the relative influence of each mode on the combined response. Thus, in Fig. 16 the second mode is seen to have little influence on the combined response for impressed frequencies below about 3000 rad per sec, whereas the first mode has considerable influence throughout the entire spectrum except near the second natural frequency, or from about 8000 to 15,000 rad per sec. In a similar manner, other conclusions can be drawn from examination of Fig. 15.

Next article in this series will discuss the procedures for analyzing systems with more than two degrees of freedom.

#### REFERENCES

This article is the third in a series by Austin H. Church on simplified vibration analysis. Previous articles and issues of *MACHINE DESIGN* in which they appeared are:

1. "Mobility and Impedance Concepts" ..... February 18, 1960
2. "Single-Degree-of-Freedom Systems" ..... March 3, 1960

Other reference in this article is:

3. R. E. D. Bishop—"The Analysis and Synthesis of Vibrating Systems," *Journal of the Royal Aero. Soc. (British)*, October, 1954, p. 717.

## Tips and Techniques

### Calculating Standard Deviation

An interesting mathematical technique is used to by-pass root-mean-square calculations in statistical standard-deviation determinations.

Tabulated example problem indicates a given group of measurements in columns *a*, *b*, and *c*.

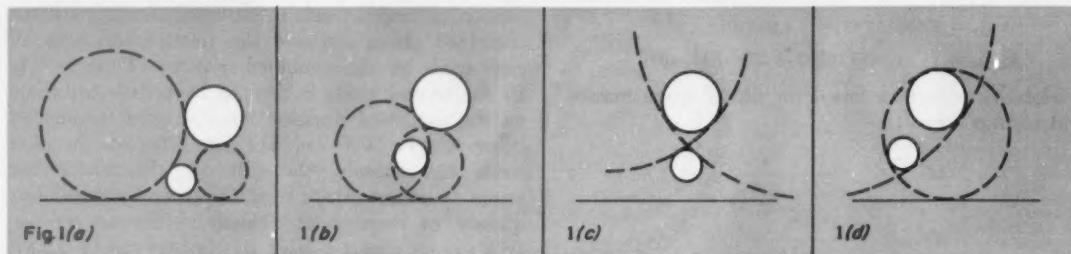
Assuming the average as some easily manipulated value, 5.00, the deviation from this value is calculated, column *d* (number times deviation). Adding the plus deviations and the minus deviations algebrai-

cally yields a sum of -0.99. The real average is then:  $5.00 - 0.99/100 = 4.99$ .

The usual method to determine average deviation is applied, column *e*. Average deviation =  $1.69/100 = 0.0169$ . For large groups of data in a normal or bell-shaped distribution, standard deviation,  $\sigma$ , is determined by multiplying the average deviation by 1.25. In the example,  $\sigma = 0.0169 \times 1.25 = 0.0211$ . —L. D. KUNSMAN, Willoughby, Ohio.

(a) Measurement	(b) Frequency Plot	(c) No.	(d) Deviation from Assumed Average	(e) Deviation from Real Average
5.05	I	1	1 (0.05) = 0.05	1 (0.06) = 0.06
5.04	II	2	2 (0.04) = 0.08	2 (0.05) = 0.10
5.03	III	4	4 (0.03) = 0.12	4 (0.04) = 0.16
5.02	IV V	8	8 (0.02) = 0.16	8 (0.03) = 0.24
5.01	V VI	9	9 (0.01) = 0.09	9 (0.02) = 0.18
5.00	VII VIII I	11	+ 0.50	11 (0.01) = 0.11
4.99	VII VII VII VII VII	25	25 (0.01) = 0.25	25 (0.00) = 0.00
4.98	VII VIII III	14	14 (0.02) = 0.28	14 (0.01) = 0.14
4.97	VII VIII II	12	12 (0.03) = 0.36	12 (0.02) = 0.24
4.96	VII VII	10	10 (0.04) = 0.40	10 (0.03) = 0.30
4.95	III	4	4 (0.05) = 0.20	4 (0.04) = 0.16
		100	- 1.49	Total 1.69

## TIPS AND TECHNIQUES

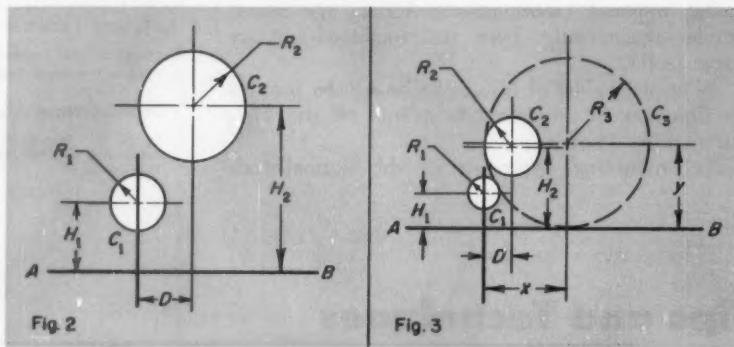


## Finding Circles Tangent to Two Circles and a Line

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PROBLEMS encountered in design of gear and rack applications occasionally require determination of a gear which will engage two other gears and a rack. Geometrically speaking, this resolves into finding a circle tangent to two given circles and a given line. A total of eight such circles are possible, Fig. 1, two of which, Fig. 1a, are externally tangent to both circles.

As shown in Fig. 2, two co-ordinate reference lines are established. The horizontal line coincides with given line  $AB$ . The vertical line passes through the center of given circle  $C_1$  at the left. Other distances are named as indicated.

Co-ordinates for centers of two circles, both tangent to circles  $C_1$  and  $C_2$  and to given line  $AB$  are given by

$$x = \frac{D}{1 - \frac{P_2}{P_1}} \pm \sqrt{D^2 - \left(1 - \frac{P_2}{P_1}\right) [D^2 + 2P_2(V_2 - V_1)]} \quad (1)$$

$$y = \frac{x^2 + 2P_1V_1}{2P_1} \quad (2)$$

where

$$P = H - R; V = \frac{H - R}{2}$$

for an external tangency, and

$$P = H - R; V = \frac{H + R}{2}$$

for an internal tangency.

The plus sign preceding the radical in Equation 1 will solve for the circle of greatest radius; the minus sign will lead to the smaller circle. The value of  $y$  from Equation 2 will also be the radius of the unknown circle. When  $P_1 = P_2$ ,  $x$  is found from

$$x = \frac{D^2 + 2P_2(V_2 - V_1)}{2D} \quad (3)$$

and only one value for  $x$  is obtained.

EXAMPLE: Required to find the smallest circle,  $C_3$ , tangent to given circles  $C_1$  and  $C_2$  and given line  $AB$ , Fig. 3. Circle  $C_3$  is to be internally tangent to  $C_2$  and externally tangent to  $C_1$ . Known values are:  $H_1 = 0.3125$ ,  $R_1 = 0.1250$ ,  $H_2 = 0.7500$ ,  $R_2 = 0.2500$ ,  $D = 0.2500$ .

Since  $C_3$  is to be externally tangent to  $C_1$ ,

$$P_1 = H_1 + R_1 = 0.4375; V_1 = \frac{H_1 - R_1}{2} = 0.0938$$

and internally tangent to circle  $C_2$ ,

$$P_2 = H_2 - R_2 = 0.5000; V_2 = \frac{H_2 + R_2}{2} = 0.5000$$

Since  $P_1$  and  $P_2$  are not equal, Equation 1 (with the minus sign preceding the radical) is used to obtain the smaller value for  $x$ :  $x = 0.7683$ . Using this value in Equation 2,  $y = 0.7683 = R_3$ . Since the value of  $x$  is positive, it is set off to the right of the vertical reference line, and circle  $C_3$  is determined.

# LOW-TEMPERATURE PROPERTIES

*of engineering materials*

How material strength and conductivity are  
affected by subzero environments

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**A**T TEMPERATURES near that of liquid oxygen (162 R or -298 F) or liquid hydrogen (38 R or -422 F), physical properties of many commonly used engineering materials differ greatly from properties at the "high" temperature of 70 F.

Some materials, notably common carbon steel, became almost as brittle as glass at low temperatures. Some disastrous mechanical failures in the early days of rocketry were attributed to this fact.

In contrast, many nonferrous metals and alloys, such as aluminum, nickel, and copper, retain or even increase in toughness as temperature drops. Austenitic stainless steels are very satisfactory in

construction of cryogenic fluid storage tanks, portable trailers, and transfer lines where weight is not critical.

Thermal conductivity of most pure metals increases greatly as temperatures are lowered. For example, thermal conductivity of pure copper at 20 R (-440 F) is about 33 times the thermal conductivity at room temperature. However, most alloys exhibit a continual decrease in thermal conductivity as temperature is lowered. Of course, all metals exhibit a thermal conductivity which approaches zero as temperature approaches absolute zero, -460 F ( $F = R - 460$ ).

Another well-known, low-temperature phenome-

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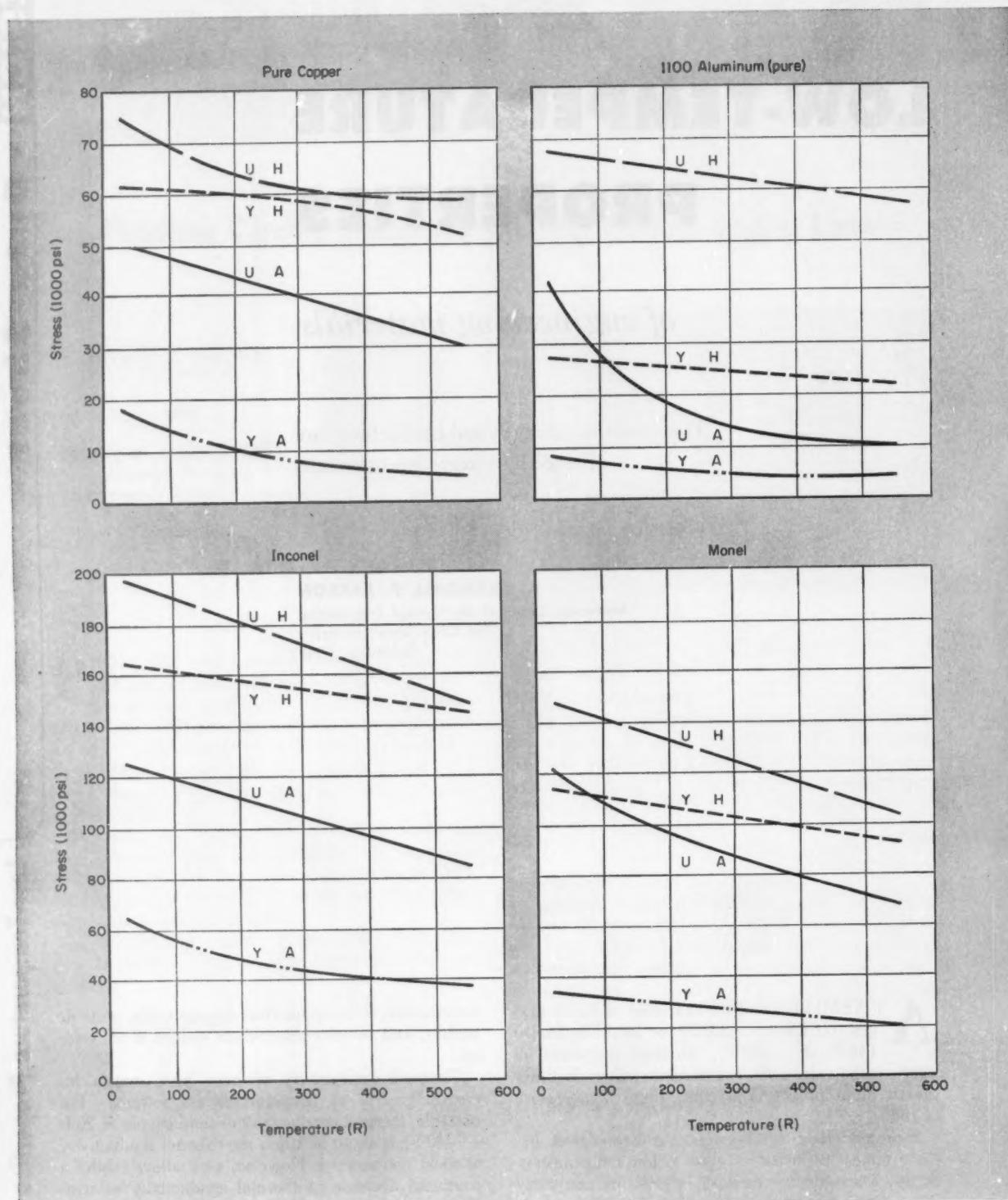
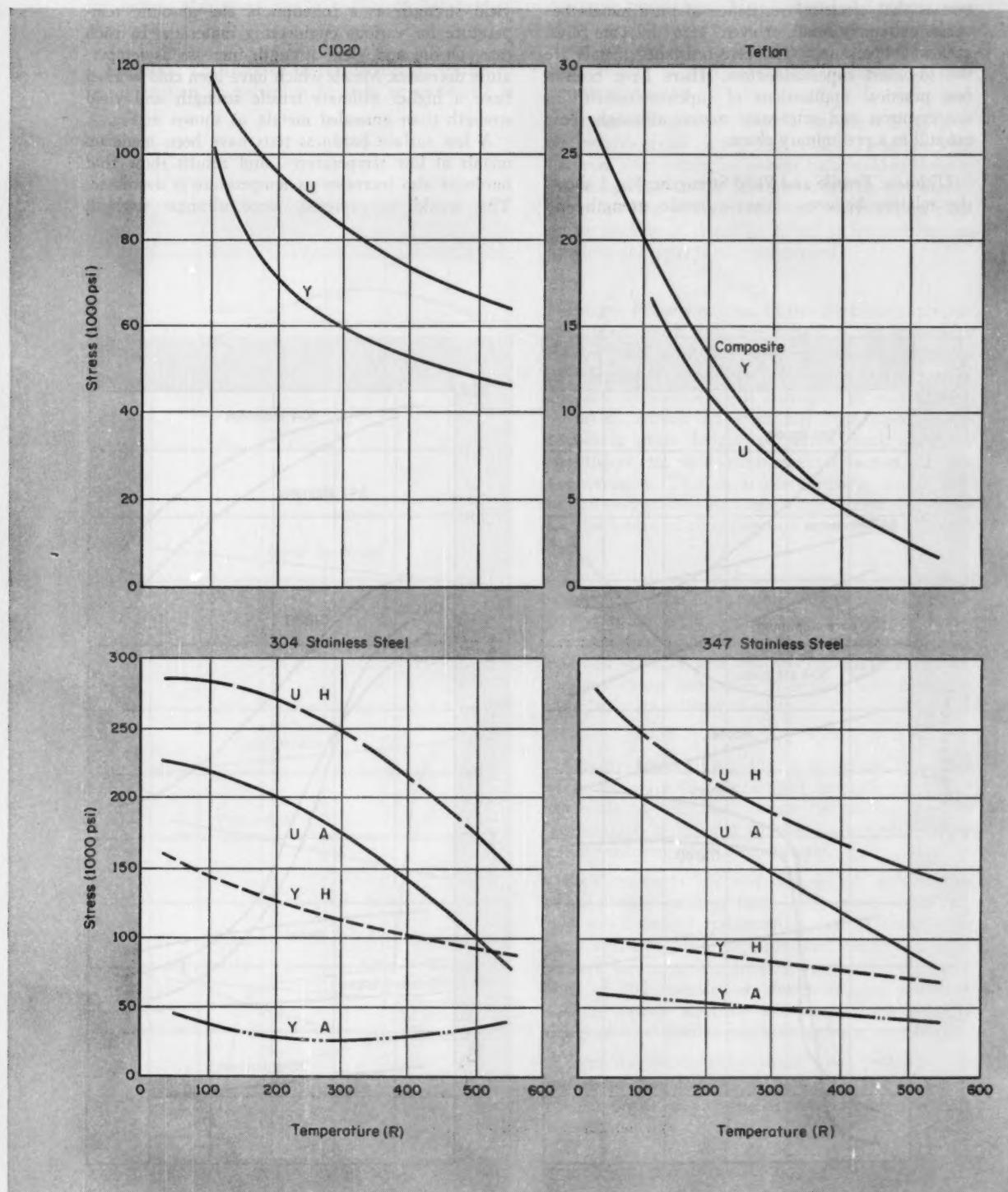


Fig. 1—Stress versus Temperature



U = Ultimate, A = Annealed,

Y = Yield, H = Hardened.

non is that electrical resistance of pure metals becomes extremely small, or even "zero" in some cases, at low temperatures. The zero-resistance metals are the so-called superconductors. There have been a few practical applications of superconductivity in the cryotron and solid-state maser, although these are still in a preliminary phase.

**Ultimate Tensile and Yield Strengths:** Fig. 1 shows the relation between ultimate tensile strength and

yield strength as a function of the absolute temperature for various engineering materials. In each case, tensile and yield strength increase as temperature decreases. Metals which have been cold worked have a higher ultimate tensile strength and yield strength than annealed metals, as shown in Fig. 1.

A few surface hardness tests have been made on metals at low temperatures, and results show that hardness also increases as temperature is decreased. This would be expected, since ultimate strength

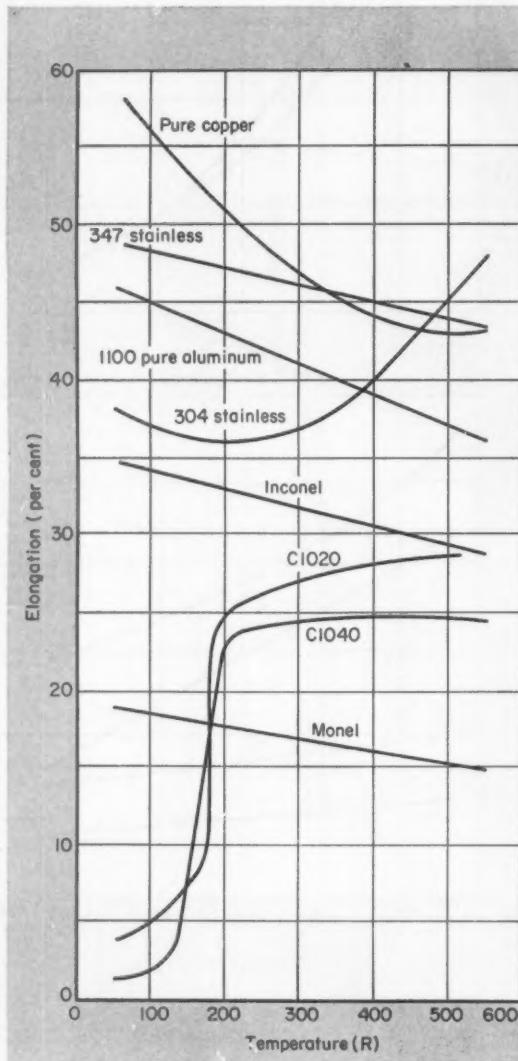


Fig. 2—Elongation  
versus Temperature

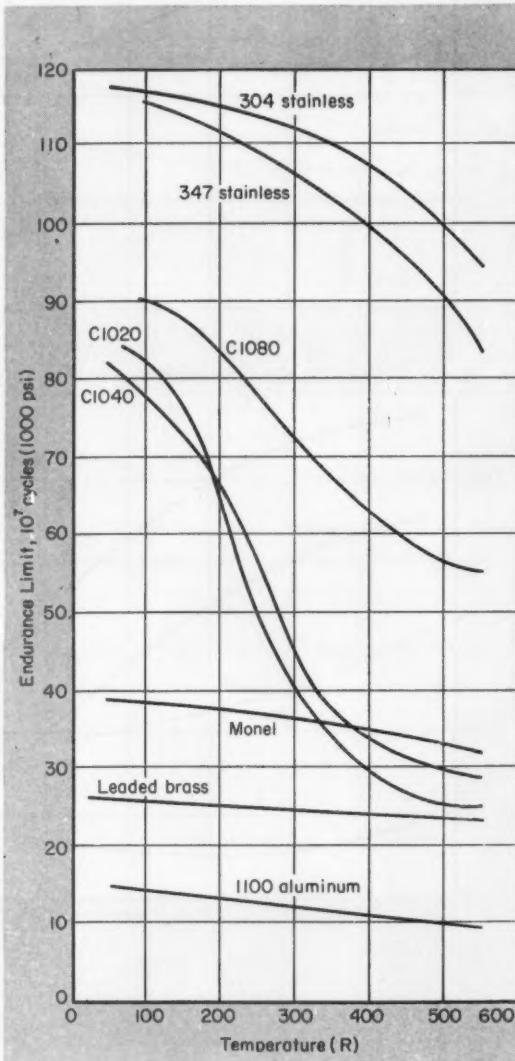


Fig. 3—Endurance Limit  
versus Temperature

for metals also gives an indication of hardness of the metal.

**Ductility:** Ductility of metals is usually indicated by elongation or reduction in area, as measured in

a simple tensile test. Fig. 2 shows the temperature effect on elongation for a few materials. The general trend for materials not adversely affected by low temperatures is that elongation increases as temperature decreases.

In the case of C1020 steel, a transition is made in the neighborhood of 170 R ( $-290^{\circ}\text{F}$ ), and the steel becomes very brittle, as shown by a sudden drop in the elongation curve. Stainless steels do not exhibit the same kind of transition, and therefore, only decrease slightly in ductility. Effect of temperature on ductility of copper is not pronounced.

**Fatigue Properties:** One of the mechanical properties about which data are meager is the endurance limit of metals at low temperatures. Fig. 3 shows dependence of endurance limit on temperature. In general, endurance limit increases as temperature decreases. Almost no work has been done in determining other fatigue properties, such as notch sensitivity and stress-concentration factors, at low temperatures. This is understandable, since it is not an easy task to maintain temperatures of  $-420^{\circ}\text{F}$  for the length of time required to complete a fatigue test.

Due to this lack of low-temperature fatigue data, common practice in dynamic designs such as transport vehicles is to employ the usual good design practices for fatigue at higher temperatures—using polished surfaces and cold-worked material, avoiding any sharp reductions in section, and designing for a fairly large factor of safety.

**Charpy Impact Test:** Fig. 4 illustrates the effect of temperature on the impact strength of a few materials. A transition occurs for carbon steel as temperature is lowered so that impact strength is greatly reduced at low temperatures.

Stainless steels 302 and 304 do not exhibit this phase change, making these steels especially attractive when impact resistance is desired along with high strength. Most high-pressure vacuum-jacketed dewars for cryogenic fluid storage have an inner shell of 304 stainless or aluminum, and an outer shell of carbon steel for economy since a properly designed outer shell is nearly at ambient temperature.

Some ductile austenitic steels, upon prolonged exposure to temperatures of about 170 R ( $-290^{\circ}\text{F}$ ), become brittle, due to partial transformation to martensitic structure.

**Thermal Conductivity:** Dependence of thermal conductivity on temperature for various materials is shown in Fig. 5. Pure metals such as copper exhibit a high maximum thermal conductivity at very low temperatures. The alloys exhibit a continually decreasing relation as temperature is decreased.

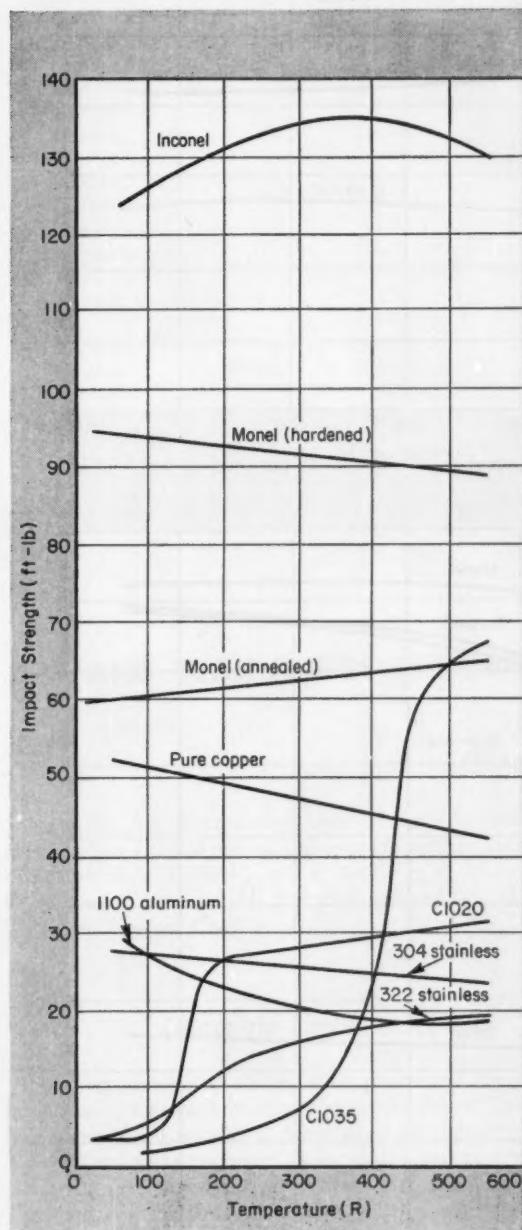


Fig. 4—Impact Strength versus Temperature

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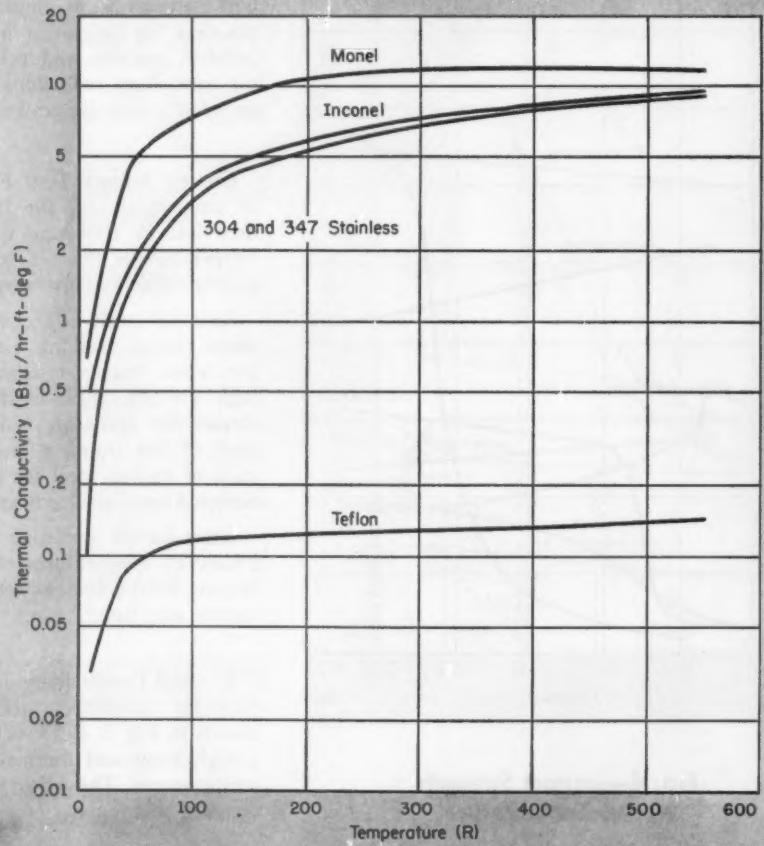
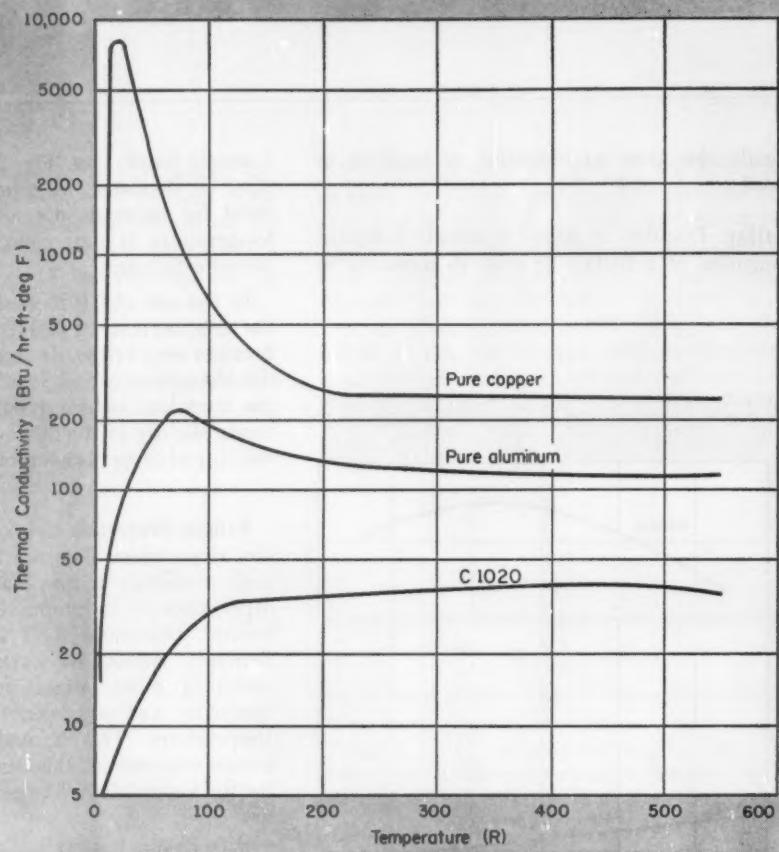


Fig. 5—Thermal Conductivity versus Temperature

**Table 1—Transition Temperature for Superconducting Elements**

Element	Transition Temperature (R)
Aluminum	21.20
Cadmium	1.01
Hafnium	19.90
Indium	6.07
Lanthanum	7.87
Lead	13.00
Mercury	7.49
Niobium	14.40
Osmium	1.28
Rhenium	1.80
Ruthenium	0.85
Tantalum	7.90
Technetium	20.20
Thallium	4.18
Thorium	2.50
Tin	6.72
Titanium	0.70
Uranium	1.44
Vanadium	9.20
Zinc	1.64
Zirconium	1.26

**Superconductivity:** Certain metals, Table 1, undergo a transition at very low temperatures and abruptly lose all traces of resistance. The phenomenon of superconductivity is more than just a state of zero resistance, but also a state of perfect diamagnetism as illustrated in the Meissner effect. When a bar is placed in a magnetic field of less than a certain value (critical field) and the bar cooled below its transition temperature, the magnetic field is expelled from the bar when it becomes superconducting.

More basic research and development need be done in cryogenics, but with information gained thus far, the engineer is equipped to make intelligent mechanical designs in the fields of liquefied gas storage, transfer and transport, heat transfer equipment, and the like. As man pushes back the frontiers of space, the subject of cryogenics becomes increasingly important to the progressive engineer.

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## TIPS AND TECHNIQUES

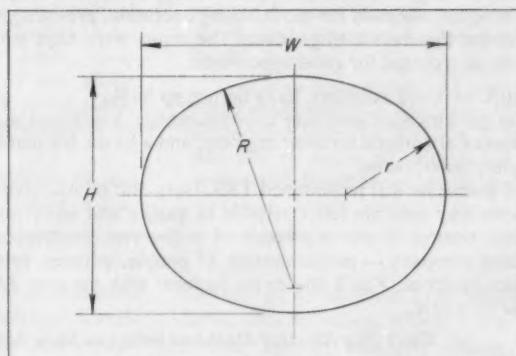
### Ellipse Formulas

Formulas for determining large radius,  $R$ , and small radius,  $r$ , for drawing approximate ellipses are:  $r = 0.683H - 0.183W$ , and  $R = W - r$ , where  $W$  = major axis and  $H$  = minor axis.—PAUL G. KNUTSON, Covina, Calif.

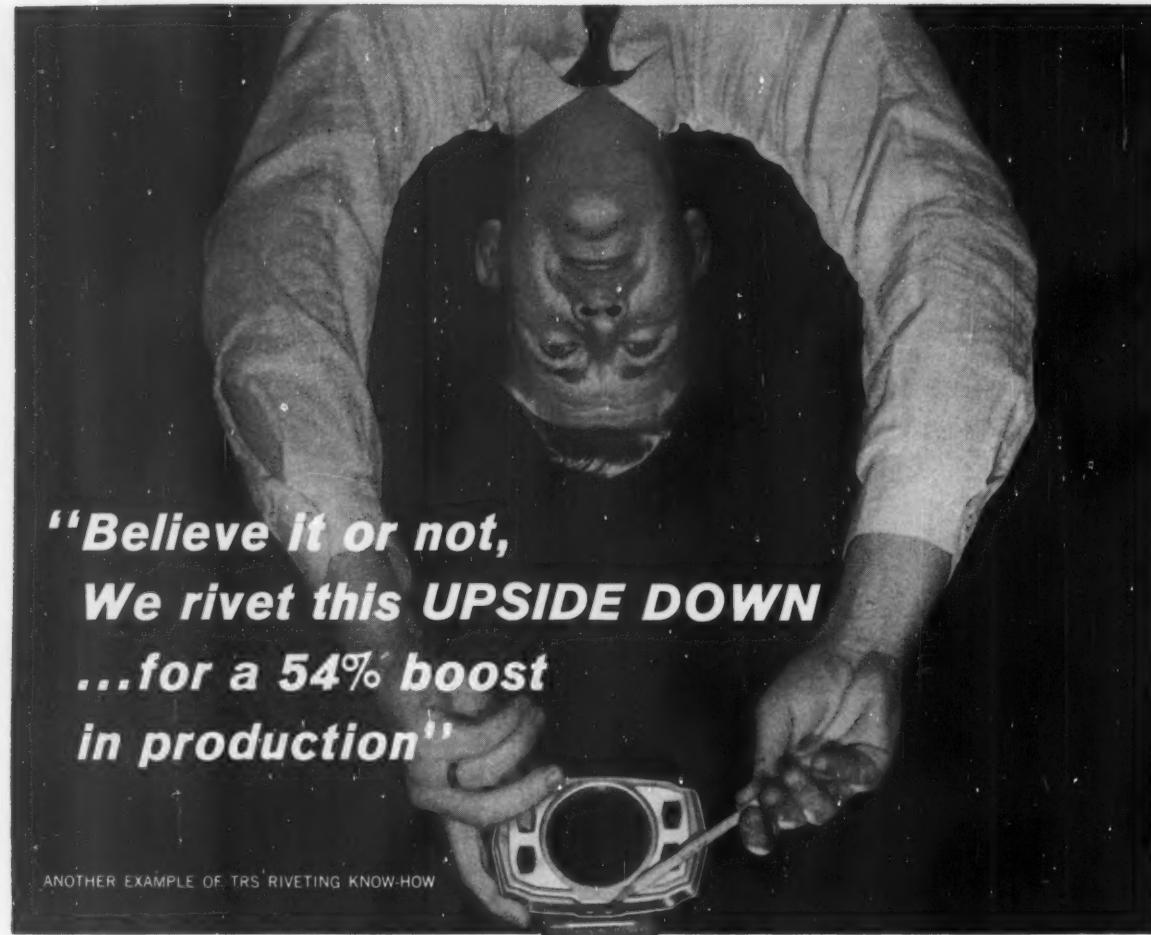
### Concentric Circles

Drawing concentric circles with purchased circle templates is awkward because the center line of the hole series is not parallel to the edge of the template. This difficulty can be remedied by gluing two plastic pieces on the template, protruding over the edge. The protruding edges are aligned parallel with the hole centers. In use these edges bring the center of each hole in turn, over the same point, as the template is slid along a straightedge.

—GEORGE VARGA, designer, Newark, N. J.



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# Mechanical Joints in Reinforced Plastic Structures

ERIC L. STRAUSS The Martin Co. Baltimore, Md.

**I**N recent years, reinforced plastics have become accepted engineering materials because of their durability, formability, and other advantageous physical properties. An additional factor is their ability to be joined to metal or other plastic parts by a variety of conventional fastening techniques. Bonding, bolting, riveting, threaded fasteners, staples, and self-tapping screws are some of the techniques successfully employed. For joining structural components, however, the choice of a method of attachment is narrowed to bonding, bolting, or riveting.

This paper deals with the design of bolted or riveted joints. Numerous applications can be cited. Parts requiring periodic replacement or removal for repair must be attached by mechanical means. Thick sections and joints transmitting highly concentrated shear loads should be jointed mechanically to avoid the possibility of overloading a bonded joint. Joints subjected to complex loadings which tend to introduce tensile or peel forces in the joint should be mechanically attached since bonded joints are weak in tension and peel.

Mechanical joining of reinforced plastics is a straightforward pro-

## Design Criteria for Mechanical Joints

The number of fasteners, fastener size, and spacing should be selected so that the joint is critical in bearing. This means that as the load on the joint is increased, the bearing strength of the laminate is exceeded before the load reaches the tensile strength of the plastic or the shear strength of the plastic or fastener. Catastrophic failure of the joint in tension or shear is thereby prevented.

Stress concentrations exert a dominant influence on the magnitude of the allowable design tensile stresses in reinforced plastic joints. Generally, only 40 to 50 per cent of the ultimate tensile strength of the plastic laminate is retained in a mechanical joint.

Multiple rows of fasteners are desirable in reinforced plastic joints.

Multiple rows permit a more gradual load transfer between the joined members, and reduce stress-concentration effects. Multiple rows of fasteners are required in unsymmetrical joints (lap joints and single-shear butt joints) to counteract the bending induced by eccentric loading.

The local reinforcing of a joint to increase its tensile strength should be avoided because only small increases in load carrying capacity are obtained, and the increased eccentricity in unsymmetrical joints gives rise to greater bending stresses.

Since stress concentration and eccentricity effects cannot be calculated with a consistent degree of accuracy, it is advisable to verify all critical joint designs by fabricating and testing representative sample joints.

cedure involving drilling, countersinking, riveting, or bolting. Standard machine-shop tools and equipment can be used.

The main disadvantage of a mechanically fastened joint is the reduction in strength due to the fastener holes. Since drilling of fastener holes removes part of the load-carrying material, a proportional re-

duction in strength is unavoidable. Stress concentration effects cause a further loss in strength. Often, a mechanical joint is the weakest part of a reinforced plastic structure.

**Joints for Plastics Attachment:** Conventional types of joints are employed to fasten reinforced plastics to themselves or to metals. In these

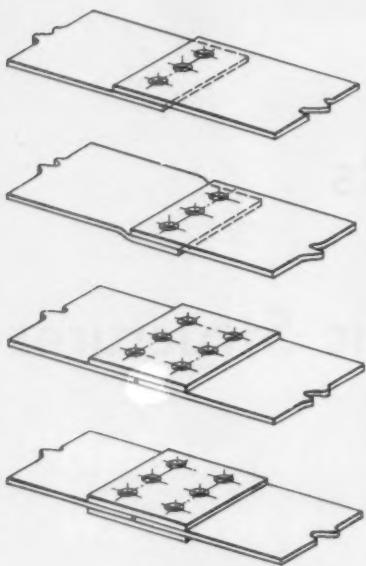


Fig. 1—Types of mechanical joints, from top to bottom: Straight lap, offset lap, single-shear butt, and double-shear butt.

joints, loads transmitted from one member to another are reacted by bearing stresses between the reinforced plastic member and the fastener, and by shear in the fastener. These shear connections are classified either as lap joints or as butt joints, Fig. 1.

In a lap joint, the two members are joined directly one to another. The connection in butt joints is made by fastening each member to one or a pair of butt plates. The double-shear butt joint is the only symmetrical configuration. In the other types of joints the lack of symmetry induces bending because the opposing forces do not lie in a common plane. Bending produces a nonuniform stress distribution

Table 1—Strength of Tension and Joint Specimens

Hole Pattern	Specimen Width (in.)	Tensile Strength Ratio	
		For Tensile Specimen With Hole Pattern	For Double-Shear Butt Joints
Single hole	1	0.70	0.51
Two holes in line	1	...	0.67
Row of holes, 1-in. pitch	4	0.72	0.40
Triple row of holes, 1-in. pitch, 1/2-in. back pitch	4	0.66	0.41

- Notes: 1. All holes  $\frac{1}{4}$  in. diameter.  
 2. Tensile specimens are  $\frac{1}{8}$ -in. thick glass-fabric polyester laminates.  
 3. Joint specimens are  $\frac{1}{8}$ -in. thick glass fabric laminate with  $\frac{1}{16}$ -in. thick 2024 aluminum alloy butt plates fastened by  $\frac{1}{4}$ -in. aluminum bolts and nuts.  
 4. Tensile strength ratio = average stress at failure/tensile strength of plastic laminate.

through the thickness of the plastic members. If the members forming the joint are flexible and free of restraint, bending stresses are minimized.

**Failure in Mechanical Joints:** When a reinforced plastic structure is mechanically attached to plastic or metal, failure can occur in the plastic member in three ways: 1. Tensile failure through a line of fasteners. 2. Shear tearout of the fastener. 3. Bearing failure in the plastic.

A compression load on a bolted or riveted joint is transmitted by bearing forces of fastener against plastic, and compression in the plastic. A bearing failure is the prevalent mode of failure in joints loaded in this manner.

If a structure containing a sym-

metrical joint is subjected to a tensile load, only tensile stresses are produced in each plastic member. The stresses are uniform through the thickness of the plastic. If a similar tensile load is applied to a structure containing an unsymmetrical joint, the maximum tensile stresses at the adjacent faces will be higher. Consequently, unsymmetrical joints are prone to fail in tension. Failure due to bending, bearing, and shear can also occur in the fastener.

Tensile failure occurs at the weakest point in a mechanical joint. The locus of minimum strength in a joint runs through a row of fasteners because fastener holes reduce the cross-sectional area and because of stress-concentration effects. Tensile failures in reinforced plastic joints start with the forma-

Table 2—Effectiveness of Reinforcing Schemes

Specimen No.	1	2	3	4
Reinforcement	None	$2\frac{1}{4}$ in. diam cover plate, $\frac{1}{8}$ in. thick, one side only, attached by 8 bolts	$1\frac{1}{16}$ in. aluminum alloys strips on both sides, attached by bonding and riveting	$1\frac{1}{16}$ in. hexagonal patch, laminated to face, both sides
Location of Failure	Through 1-in. hole	Through series of 3 bolt holes	Through upper rivet holes	Through 1-in. hole
Tensile Efficiency, (per cent)	41.5	50	40.5	61.5

- Notes: 1. Tensile efficiency is based on tensile load sustained by a 3-in. wide specimen without holes.  
 2. Dimensions of all specimens are: 3 in. wide,  $\frac{1}{8}$  in. thick, 1 in. diam hole.



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### DESIGN ABSTRACTS

tion of small cracks at the edge of a fastener hole. The crack spreads rapidly to the edge of the specimen or toward an adjacent hole.

Shear tearout failures can occur either by shearing out a plug between the fastener hole and the end of the laminate or by pulling the fastener head through the laminate. The latter failure is usually induced by secondary bending in unsymmetrical joints, and a majority of these failures occur in joints fastened with countersunk head screws or rivets.

Bearing failures in reinforced plastic laminates are not catastrophic failures, for this type of failure results from excessive deformation rather than fracture of the material. By definition, the bearing strength of a reinforced plastic is the stress level at which the deformation of the hole exceeds 4 per cent of the hole diameter. This degree of deformation causes the fastener hole to deform into an oblong shape. The hole deforms elastically to approximately 1.5 per cent, and then the resin at the edge of the hole cracks and powders.

When a joint is stressed to its ultimate bearing stress, the material is still able to sustain load. Additional stressing continues to deform the hole and weaken the material until fracture finally occurs in tension or shear.

**Strength of Bolted or Riveted Joints:** Stress concentrations induce tensile failures in reinforced plastic joints at stress levels well below the tensile strength of the plastic laminate. Stress distribution in the vicinity of stress raisers is not influenced by the particular manner in which load is applied. However, if the load is applied close to or directly at the stress concentration, as it is in the case of a hole loaded by a pin bearing against its edge, a different stress pattern occurs.

Mechanical joints induce considerably greater stress concentrations in plastic laminates than do uniformly loaded tensile specimens containing equivalent hole patterns, Table 1. Tensile specimens fail at an average stress level ranging from 66 to 72 per cent of the tensile strength of the plastic laminate. Failure in joint specimens occurs at

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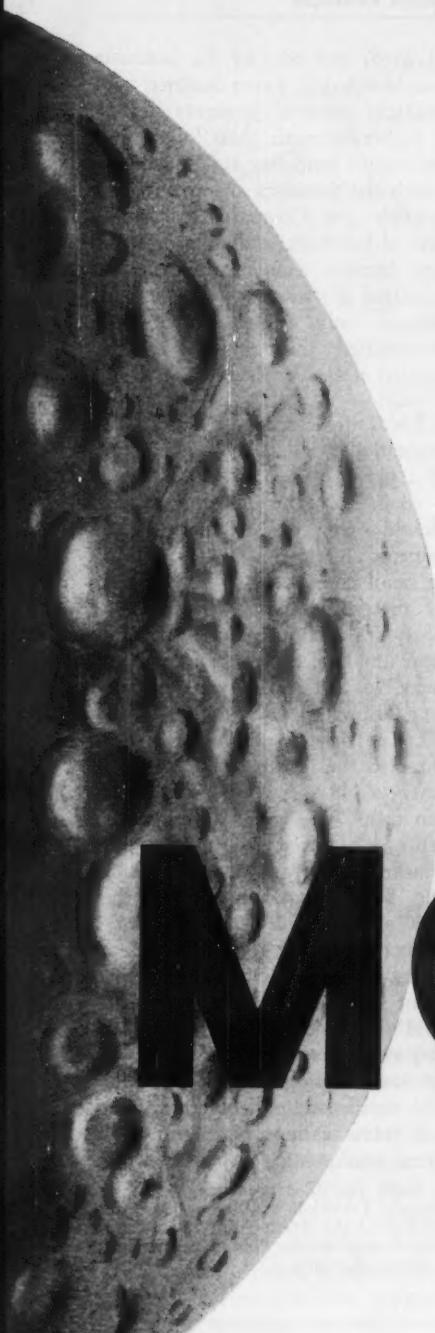
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41 to 67 per cent of the laminate tensile strength. Joints fastened with multiple rows of fasteners display a higher strength than joints with equivalent hole size and spacing in which the fasteners are arranged in a single row. Compared to a single row of fasteners, a double or triple row imparts a more uniform distribution of stresses to a plastic joint because only a part of the load transmitted through the joint is reacted at each row.

**Local Reinforcing at Stress Concentrations:** The local reinforcing of a plastic component to overcome a deficiency in tensile strength should be avoided. In this case, the increase in load-carrying capacity is small compared to the thickness of material added. Characteristics of typical reinforcing schemes appear in Table 2. There, in Specimen No. 2, the cover plate resulted in a 20 per cent increase in strength. The patches in Specimen No. 4 doubled the thickness but produced only a 48 per cent increase in strength. The great difference in stiffness between aluminum and plastic actually caused Specimen No. 3 to fail at a lower load than the unreinforced Specimen No. 1.

Increasing the thickness of laminates comprising an unsymmetrical joint increases both the eccentricity and the bending rigidity and consequently results in significantly greater bending stresses. Therefore, the tensile strength of unsymmetrical joints cannot be improved by local reinforcing.

*Paper No. 12-A presented at the 15th Annual Technical and Management Conference of the Reinforced Plastics Div. of the Society of the Plastics Industry Inc., Chicago, February, 1960, 7 pp.*

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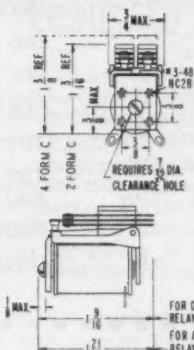
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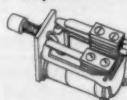
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**Shock:** 30g on special order.

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have been eliminated. The synchronizing function and pull-out protection are automatically provided by a simple static circuit which uses two silicon-controlled rectifiers and Zener diodes. The new motor can be started like a squirrel-cage induction motor with a standard full or reduced voltage starter. The adjustable power-factor correction of the conventional synchronous motor is retained.

*AIEE Paper No. 60-127 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 5 pp.*

### Electron Tubes or Semiconductors?

*E. E. Scheneman and S. K. Waldorf  
Westinghouse Electric Corp.*

Summary and comparison of numerical data on electron tubes and semiconductor devices to serve as a guide in areas where both types of devices might be used. Tables compare performance under varied environmental conditions and two categories of electrical conditions.

Distinctive characteristics of semiconductor devices are:

1. No cathode heater power is required.
2. Low mass and small volume are generally provided, leading to high resistance to mechanical shock and vibration.

Distinctive characteristics of electron tubes are:

1. Very high electric resistance between tube elements is available for isolation of circuits.
2. Operating temperatures can exceed about 175°C.
3. Very high voltages can be rectified, converted, or utilized.

Also, electron tubes are now made in small sizes with volume as low as 0.58 cc and mass as low as 1.6 grams.

*AIEE Paper No. 60-74 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 9 pp.*

## hydraulic

### Supersonic Diffuser in Radial And Mixed-Flow Compressors

*F. Dallenbach, Assistant to the Chief Engineer, AiResearch Mfg. Co., and N. Van Le, Research Scientist, The Garrett Corp.*

Design concepts of a novel diffuser that handles supersonic flow at the

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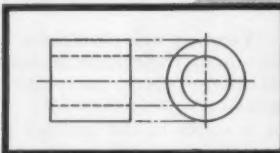
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## DESIGN ABSTRACTS

exit of radial and mixed-flow compressors. The guide vanes incorporating a V-shape at the inlet are shown to offer potentialities of a shock-free deceleration of the supersonic flow.

Under stationary test, an efficiency of 79 per cent was achieved for the diffusing system operating with an inlet Mach number of 1.3 behind stationary nozzles.

A centrifugal compressor having a supersonic impeller and the diffusing system under study was shown to operate at 4.3 pressure ratio with an efficiency of 75 per cent.

ASME Paper No. 60-Hyd-11, presented at the Gas Turbine Power & Hydraulic Conference, Houston, Texas, March, 1960, 7 pp.

## A Jet Pump Design Theory

T. W. Van Der Lingen, Senior Research Officer, National Mechanical Engineering Research Institute, Pretoria, South Africa.

A compressible flow jet pump theory which can be easily interpreted for design purposes. It consists of a one-dimensional analysis based on the momentum equation and on complete mixing, used in conjunction with an over-all pressure recovery factor which is found experimentally. Tests on a small jet pump indicate that for each general pump configuration one correlating curve applies to all operating conditions. In this way, a comprehensive theory is established, from which the delivery pressure of a pump under any operating conditions in practice may be determined once its pressure recovery factor curve has been established.

ASME Paper No. 60-Hyd-6, presented at the Gas Turbine Power & Hydraulic Conferences, Houston, Texas, March, 1960, 14 pp.

## materials

### Behavior of Sheet Materials In Bending

Bernard W. Shaffer, professor of mechanical engineering, New York University, and Eric E. Ungar, senior engineering scientist, Bolt, Beranek and Newman Inc.

Two sets of expressions for residual stresses and deformations resulting from bending processes in which initially flat sheets are permanently

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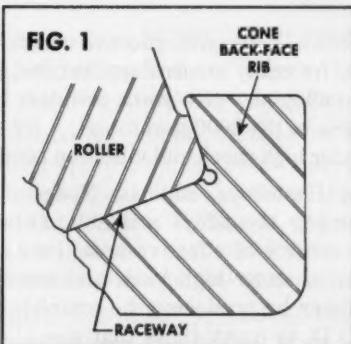


## BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

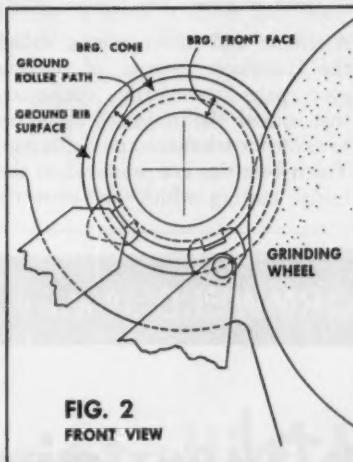
Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under



load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

In the design and manufacture of Bower tapered roller bearings, Bower engineers take great care to generate and hold an exact face angle on the cone back-face rib. In practice, this means that Bower



**FIG. 2**  
FRONT VIEW

bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.

It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass

Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.



★ ★ ★ ★

When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

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deformed to shapes having measurable radii of curvature. One of these sets applies for radii of curvature, under load, which are greater than 0.84 times the sheet thickness, and is associated with a residual plastic zone in the interior of the sheet. The other set applies whenever the radii of curvature are less than 0.84 times the sheet thickness, and is associated with residual plastic zones in the bar interior and near the concave boundary of the sheet.

*ASME Paper No. 59-A-35 presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 7 pp.*

## mechanical

### Measurement of Very Low Frictional Torques

*M. Zaid, Technical Consultant, Technik Inc. and I. S. Tolins, Principal Engineer, Ford Instrument Corp.*

Two techniques for the measurement and discrimination of frictional torques of 5 dyne-cm or lower. These methods can be classi-

fied as decrement techniques. Along with the well-known log-decrement method associated with viscous damping, they take into account the variation from free rotation conditions. The approaches introduce new concepts that could prove useful in the study of dynamic systems with friction elements.

*ASME Paper No. 59-A-43, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 5 pp.*

## processes

### Design Relationships for New Gear-Making Process

*G. M. Spear, Research Engineer, C. B. King, Associate Chief Research Engineer, and M. L. Baxter, Jr., Chief Research Engineer, The Gleason Works*

A simple and direct means, called the Helixform process, of making gear pairs practically conjugate, that is, with the mismatch necessary to allow for tolerance and deflection. Tooth bearings are produced at the initial cutting which are correctly

shaped for the delivery of uniform motion. With the Helixform process, the surfaces of the gear teeth are basically involute helicoids. As such they are made up of straight line elements and are ruled, developable, synclastic surfaces. With Helixform gears, the helices of the tooth surfaces are slightly inclined to the peripheral direction of the cutter by the lead angle.

*ASME Paper No. 59-A-90 presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 12 pp.*

## techniques

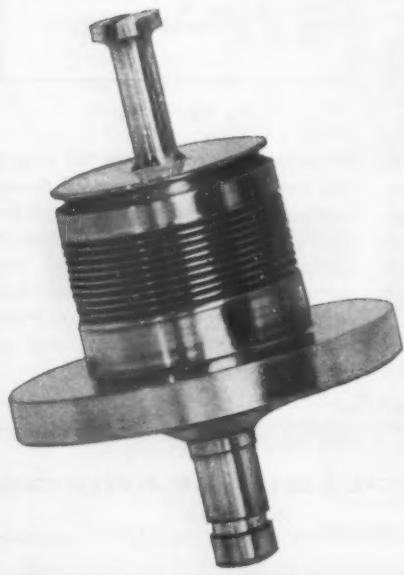
### Merits of Incremental and Ordinary Digital Computers

*S. M. Shackell, Stevens Institute of Technology, and J. G. Tryon, Bell Telephone Laboratories.*

Evaluation of relative merits of the two designs which are used in airborne real-time control and, very extensively, in industrial process control. The essential difference is this: In the incremental computer,

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the intermediate quantities and outputs are retained from cycle to cycle and brought up to date in each cycle. Changes in the inputs since the last calculation are propagated through the calculation, as changes in the intermediate quantities, to become changes in the outputs.

In the conventional computer, the intermediate quantities and outputs of one cycle are discarded and have no use in the next recalculation. Each quantity is recomputed afresh in each cycle. There is no essential holdover from previous cycles.

*AIEE Paper No. CP60-120, presented at the AIEE Winter General Meeting, New York, January-February, 1960, 19 pp.*

### Guide to Automotive Engineering Literature

Eugene B. Jackson, Research Laboratories, General Motors Corp., Eleanor V. Wright, Engineering Div., Chrysler Corp., and Rachel MacDonald, Engineering and Research Staff, Ford Motor Co.

A "five-foot shelf" of literature listed in eight major groups according to

physical form and presentation of content. The bibliography includes sources of information on standards and specifications, college and university publications, technical society preprints, and manufacturers' literature. In general, items in the bibliography dated before 1945 are considered classics.

*SAE Paper No. 124C, presented at the SAE Annual Meeting, Detroit, January, 1960, 21 pp.*

### The Big Picture Of Systems Analysis

Merrill M. Flood, University of Michigan, Ann Arbor, Mich.

Techniques of systems engineering which are widely applicable in other engineering fields. The strategy in approaching a complex problem is to break it down into manageable pieces. Two ways are:

1. Create mathematical models, each of which represents some part of the entire system, together with an overall system model either in mathematical form or in some other form such as a flow diagram.

2. Write verbal descriptions of subsystems, and their interconnections, to show the main outlines of the system and its functions.

The goal is to go as far toward mathematical precision as is economically desirable and technically feasible. Physical models, computer simulations, and other techniques are in the scope of "mathematical precision."

*SAE Paper No. 113A, presented at the SAE Annual Meeting, Detroit, January, 1960, 15 pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.

SPI—Society of the Plastics Industry Inc., 250 Park Ave., New York 17, N. Y.

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# Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

## Nut Fasteners

New brochure contains all basic engineering data and specifications on hexagon nuts, sizes  $\frac{1}{4}$  to 3 in., 12-pointer nuts, sizes  $\frac{1}{4}$  to  $\frac{3}{4}$  in., and Conelok, Huglock, and Marsden lock nuts, sizes  $\frac{1}{4}$  to  $1\frac{1}{2}$  in. Included is a section providing information on fastener design, gages, stress area, bolt tightness and wrench torque, thread series, and applications. National Machine Products Co., 44225 Utica Rd., Utica, Mich.

Circle 701 on Page 19

## Laminated Plastics

Catalog 20.000.13 provides engineering data, product descriptions, and wide uses for complete line of Insurok laminated plastic sheets, rods, tubes, and fabricated parts. Typical products are shown, and manufacturing techniques, research, development, and custom molding are described. 8 pages. Richardson Co., 2731 Lake St., Melrose Park, Ill.

Circle 702 on Page 19

## High-Reliability Capacitors

Wide variety of capacitor types and case styles, including high-voltage midgates, metallized paper, Mylar or Teflon, Kraft-Mylar, and foil missile miniatures, are featured in revised capacitor catalog. Complete electrical specifications, temperature characteristic graphs, and construction details are presented for engineering reference. 16 pages. Marshall Industries, Electron Products Div., 2065 Huntington Drive, San Marino, Calif.

Circle 703 on Page 19

## Static Spring Seals

Bulletin 101SD discusses high-temperature, high-pressure, static spring seals. Information is provided on the principle, sizes and types, and typical installation diagrams are furnished. Temperature range of the seals is from -400 to +2000 F. Hydrodyne Corp., Skinner Seal Div., 7350 Coldwater Canyon, North Hollywood, Calif.

Circle 704 on Page 19

## Positioning, Program Controls

Bulletin J-105 features an expanded line of linear and rotary actuators, 20 sizes delivering torques from a few ounces-inches to 3500 lb-in. It also contains information on six basic types of remote positioners from low-cost relay types to power-transistor units with resolutions to one part in 250,000. Also included are data on machine tool point-to-point position and rate control, punch-card formula and program control, and closed-loop

process control. 16 pages. Jordan Controls Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 705 on Page 19

## Self-Retaining Rubber Parts

New folder describes Cooper Clips and self-retaining rubber components for bumpers, spacers, feet, or mounts. Two basic styles, dynamic and static, are available in 6 basic designs. Folder gives information on applications, types, and materials. 4 pages. Cooper Tire & Rubber Co., Industrial Rubber Products Div., Findlay, Ohio.

Circle 706 on Page 19

## Machining Steels

Engineering data on Ledloy 375 and 300 cold-finished steel bars, and Ledloy 170 cold-drawn steel tubing, are provided in Technical Bulletin 12-10. Cost and cutting-speed comparisons, mechanical properties, chemical compositions, case histories, and data on tubing versus bar stock are included. 8 pages. Joseph T. Ryerson & Son Inc., Box 8000-A, Chicago 80, Ill.

Circle 707 on Page 19

## Chain and Sprockets

Extensive line of roller chain and Taper-Lock sprockets is presented in illustrated Bulletin A691. Nearly all roller-chain requirements can be met with the expanded line and standard attachments. Photographs and diagrams show construction details. Bulletin also includes general information on the installation of roller-chain drives, calculation of center distances, horsepower ratings, conveyor engineering, and instructions for lubrication and maintenance. 56 pages. Dodge Mfg. Corp., Mishawaka, Ind.

Circle 708 on Page 19

## Radial Ball Bearings

R and 30-Series ball bearings are extralight inch and metric-dimension units, respectively. They are described and illustrated in Bulletin 112, including variations, sizes, capacities, and other pertinent data. 4 pages. Hoover Ball & Bearing Co., Bearing Div., 5400 S. State Rd., Ann Arbor, Mich.

Circle 709 on Page 19

## Fasteners

Profusely illustrated Catalog 8-483 describes complete line of Huck fasteners. It includes discussion of a broad variety of tension and feather-weight Huckbolt fasteners, self-broaching fasteners, self-sizing fasteners, pull-through blind rivets,

friction-lock, self-plugging blind rivets, and lock-spindle, self-plugging blind rivets. Driving cycles, strength data, typical applications, grip ranges, dimensional data, hole-size recommendations, and installation notes are included for each fastener. 24 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.

Circle 710 on Page 19

## Mercury-Switch Controls

Catalog 860 lists mercury-switch-equipped controls for single-stage pressure, two-stage pressure, differential pressure, single-stage temperature, two-stage temperature, liquid level, and mechanical movement. Also illustrated are transformer-relays and complete line of hermetically sealed mercury switches. Each control, with accompanying description, specifications, and engineering data, can be located easily by use of a dual index provided. 56 pages. Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.

Circle 711 on Page 19

## Flange Connections

Complete line of flanged connections (with SAE bolt spacing) for connecting larger tube and pipe sizes to hydraulic components is described in new catalog. Thirty specific models, varying in type of line attachment, angle of flow, male or female form, and tee combinations, are available. 16 pages. L & L Mfg. Co., 21590 Hoover Rd., Warren, Mich.

Circle 712 on Page 19

## Stationary Compressor

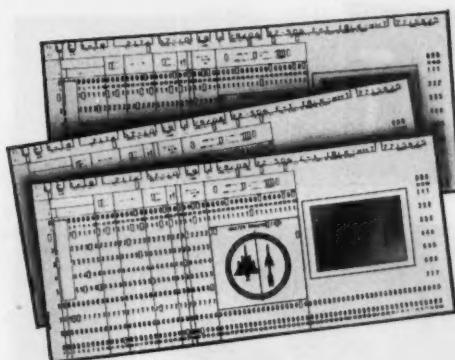
WN-114 stationary compressor is described in Bulletin A-72. Booklet includes specifications on three basic models of the semiradially constructed units ranging from 1385 to 1948 cfm at 125 psi. Information on package design, components, intercooling, lubrication, motor mountings, and accessories is fully illustrated and explained. 24 pages. Joy Mfg. Co., Henry W. Oliver Bldg., Pittsburgh 22, Pa.

Circle 713 on Page 19

## Titanium Fabrication

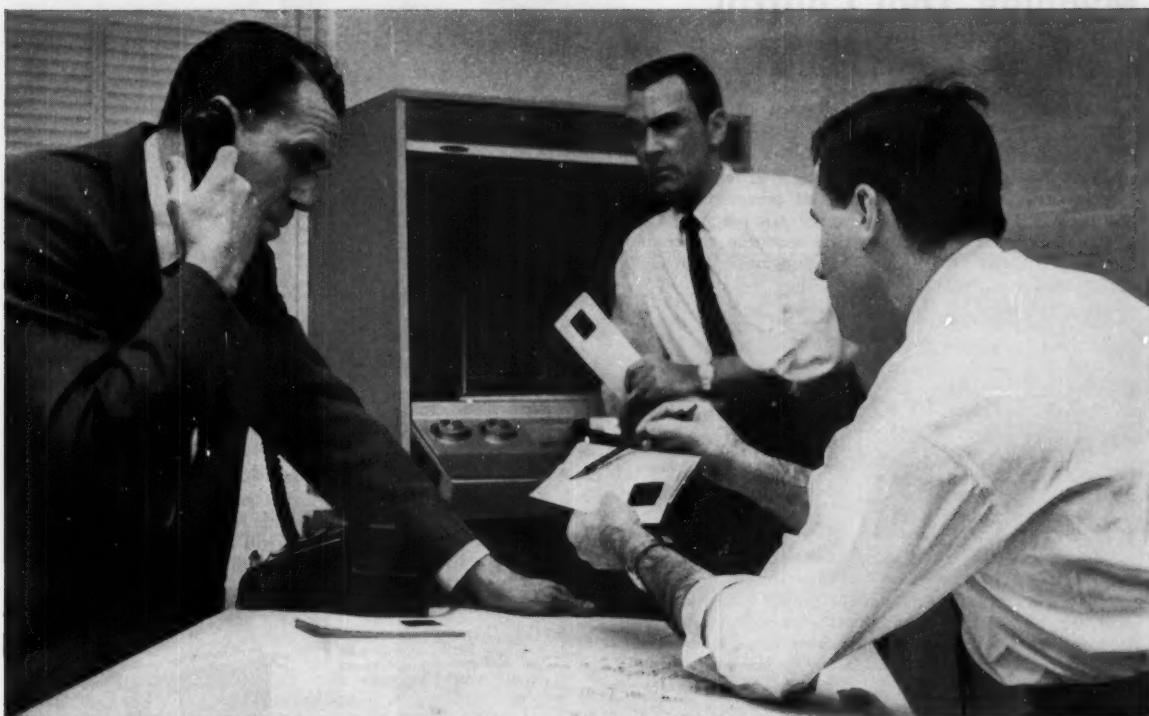
Booklet 3 in a series is intended to assist in the procurement and use of titanium and titanium alloy. It contains complete data on the latest approved methods of fabricating and welding titanium and titanium alloys. Chart of physical and mechanical properties is included. 24 pages. Republic Steel Corp., Advertising Div., 1441 Republic Bldg., Cleveland 1, Ohio.

Circle 714 on Page 19



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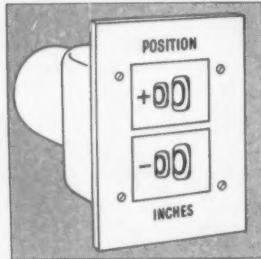
# Veeder-Root

# READOUT

# Bulletin

## Readout Counter used in Tape Preparation for Machine Tool Control

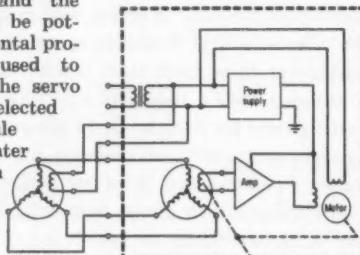
A Veeder-Root Series 1538 Remote Data Readout Counter provides tape feed control for the motorized tape punching unit of the new Potter & Johnston Tape Control System. The tape punch is used to program machine functions on P & J Automatic Turret Lathes. The counter automatically controls the amount of tape feed required for each turret face involved, and stops the tape at preselected address points. When the correct address point is reached, a combination of holes representing the machine command is punched into the tape. Counter is automatically reset for each turret face.



### Servo Repeaters Drive Counters to Indicate Lineal Motion\*

One of the ways to take advantage of digital readout for indicating and control is through servo repeaters. Applications in aircraft, for altimeters, navigational displays and similar instrumentation, suggest many other opportunities to use counters for more positive indication and control. A typical "system" is shown here where a counter is used for indicating nuclear reactor rod position.

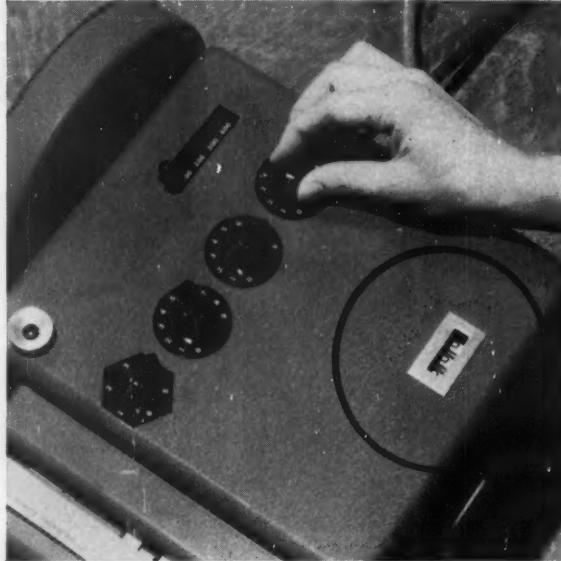
The servo repeater and counter actually form one packaged unit, and the whole device can be potted for environmental protection. When used to drive counters, the servo gear ratio is best selected to provide full scale travel of the counter for one revolution of the control transformer shaft.



Typical servo repeater/counter device  
that converts synchro data to digital readout.

**Let Veeder-Root help you make Counters do more!** Extensive design experience and precision production techniques make it possible for Veeder-Root to help you solve a wide variety of digital, readout, control and recording problems with counters — from the simplest ratchet to advanced readout and navigational devices. Send for information on specific applications or contact your local Veeder-Root Counting Engineer.

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### Veeder-Root Readout Device

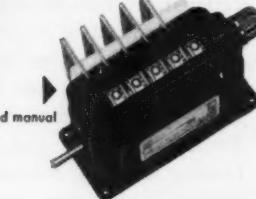
This is the basic series of Remote Data Readout Counters. Some are available for standard applications, or design variations will be submitted based on requirements. They function basically as analog to digital converters.

Series 1538/electrically reset/  
electrically actuated. Speed  
1000 cpm, 3 or 5 figure



Series 1538/electrically actuated/  
manual reset. Speed  
1000 cpm, 3 or 5 figure

Series 1606/mechanically actuated manual  
reset standard; bi-directional  
(non-reset) available. Speed  
5000 cpm, up to 5 figures



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**Electronic Components**

Latest prices, listings, and data are carried in a two-color issue of Stock Catalog 30A. Components listed include power rheostats, potentiometers, resistors, capacitors, relays, and variable transformers. Bakelite knobs and rheostat dials are also listed. Ohmite Mfg. Co., 3695 Howard St., Skokie, Ill.

**Circle 715 on Page 19**

**Blind Rivets**

Comprehensive, illustrated Catalog SL 101 provides detailed information about fastening with Pop rivets. Blind rivets are described and their advantages spelled out. Two basic types are shown, and material is provided on how to select the proper one for specific applications. Complete listing with illustrations of all the tools, both hand-operated and power type, is included on a separate page. Design data and selection chart on the rivets includes a new, easily understood coding system. 8 pages. United Shoe Machinery Corp., Pop Rivet Div., Shelton, Conn.

**Circle 716 on Page 19**

**Impact Extrusion**

Form 24, "Alcoa Impacts—Metal in Motion," provides complete information on the latest developments in the impact process, also known as impact extrusion. Among the advances outlined in the colorful, profusely illustrated booklet are increased size ranges, impact containers, and Alclad impacts. Twelve main sections outline design possibilities, tolerances, size ranges, and applications of impacts. Impact-press and secondary facilities are detailed. 35 pages. Aluminum Co. of America, 724 Alcoa Bldg., Pittsburgh 19, Pa.

**Circle 717 on Page 19**

**Centralized Lubrication**

Revised Bulletin 26-T contains information on a complete line of centralized systems of lubrication. New additions to the line have been included. Advantages of centralized lubrication, principles of operation, and system components are discussed. Illustrations of typical applications are also included. 24 pages. Eaton Mfg. Co., Farval Div., 3300 E. 80th St., Cleveland 4, Ohio.

**Circle 718 on Page 19**

**Magnetic Pulley Selection**

Factors governing the selection of electromagnetic or nonelectric, ceramic-type pulleys are fully explained in Catalog C-2000. Ceramox V ceramic magnet material, used in Perma-Pulleys, is described. Line of Perma-Pulleys, with radial pole design, and line of redesigned and improved electromagnetic pulleys, with all-welded construction, are described and illustrated. Detailed chart shows how to select proper magnetic pulley in relation to belt speed, belt width, and burden. 8 pages. Dings Magnetic Separator Co., 4740 W. Electric Ave., Milwaukee 46, Wis.

**Circle 719 on Page 19**

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## BHEW'S 1500-PSI

SERIES DOUBLE-ACTING GENERAL PURPOSE CYLINDERS are designed around component parts but custom-built to your specifications. Available in a variety of mountings with or without adjustable and non-adjustable rod ends.

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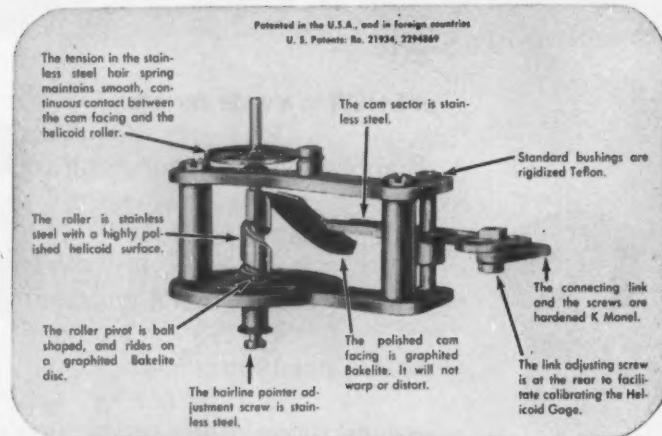


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**Circle 519 on Page 19**



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- Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that stays accurate.



### Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K. Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

### NEW! Solid-Front Safety Case Gives Added Protection



The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

**WRITE for details**



**Ask for Catalog DH-65**

# HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.  
929-M Connecticut Ave., Bridgeport 2, Conn.



### HELPFUL LITERATURE

#### Fluid-Flow Valves

Valves for fluid flow and condition control are covered in Bulletin 5911251. Introductory material details design and selection factors such as function, application, and method of actuation. Subsequent pages provide engineering data, characteristics, range specifications, and illustrations of various types of valves. United Aircraft Products Inc., Office of Technical Publications, 1116 Bolander Ave., Dayton 8, Ohio.

**Circle 720 on Page 19**

#### Limit Switch

Center-Neutral plug-in limit switch is capable of doing the work of two separate limit switches in many situations. Plug-in feature permits replacement of the switch in seconds without disturbing electrical connections. Data Sheet 168 gives full details, including photos, dimensional drawings, operating information, prices, and discounts. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

**Circle 721 on Page 19**

#### Nickel-Chromium Alloy

Detailed technical data on Chromel-R, a modified 80-20 type, nickel-chromium, 800-ohm alloy for precision wire-wound resistors and potentiometers, is presented in Alloy Data Bulletin 111. Data includes a table of physical properties, temperature coefficient curve, breaking and yield strength, wear life and load life test results, effects of winding on electrical characteristics, and recommended maximum safe winding tensions for various sizes of fine wire. Also presented are complete specification tables for both bare and enameled wire in standard sizes. 8 pages. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 2, Mich.

**Circle 722 on Page 19**

#### Heavy-Duty Chain

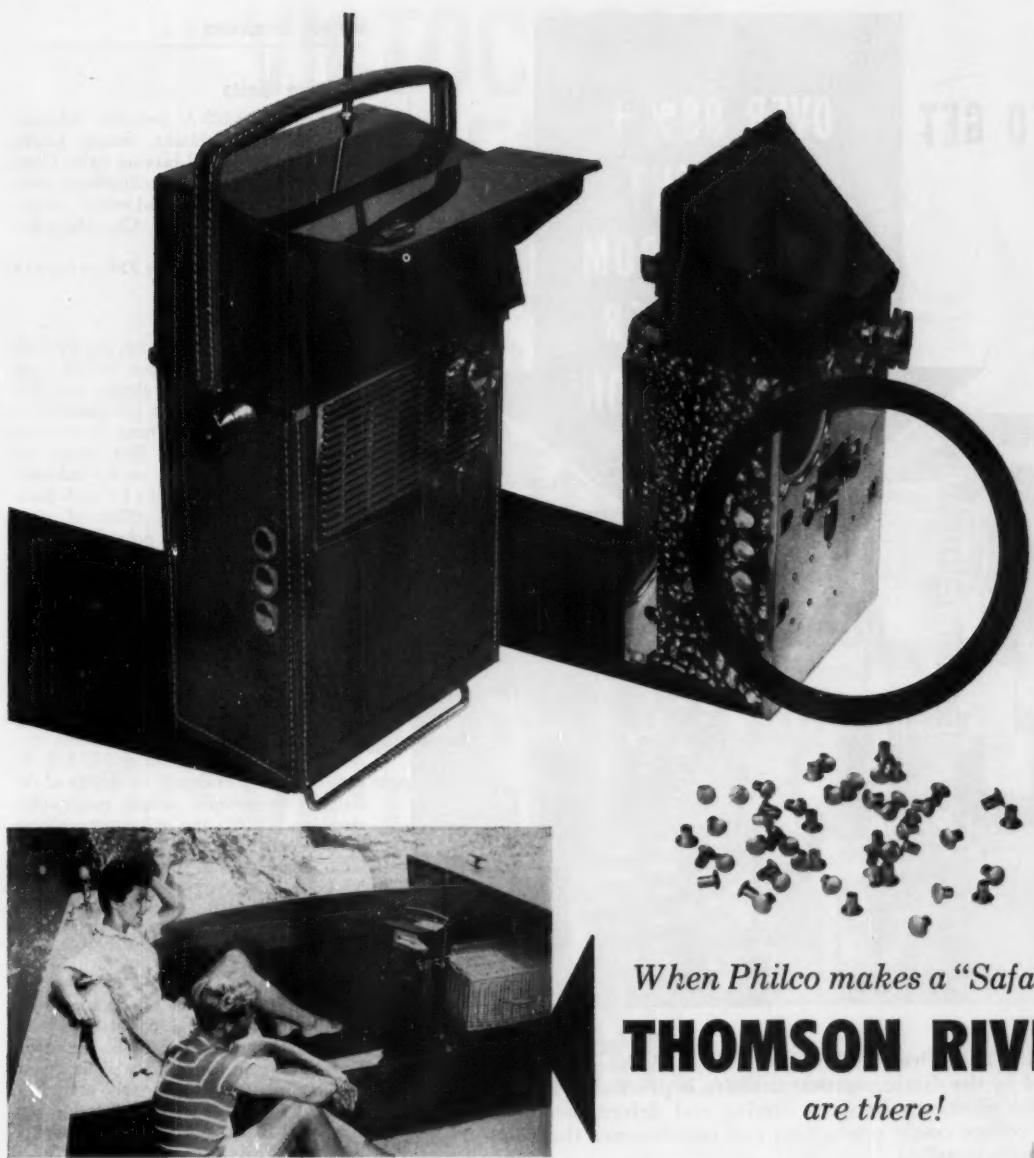
New technical folder describes offset side-bar roller chain, developed for heavy-duty applications where the operating conditions are extremely severe. Literature gives full details on the chain and drawings of its construction, as well as sizes available and sprockets to be used with it. 4 pages. Atlas Chain & Mfg. Co., Dept. FO, West Pittston, Pa.

**Circle 723 on Page 19**

#### Filtration Equipment

Catalog GEO-506A, "Complete Filtration for Liquids and Gases," provides a brief description of each of the products in a line of filtration equipment. Line includes Fulfilo, Delpark, Honan-Crane, and Michiana filters for continuous microclarification of all types of industrial fluids. Information is classified according to applications, operating pressures, and sizes. Various types of filter media are also described and illustrated. 8 pages. Commercial Filters Corp., 2 Main St., Melrose, Mass.

**Circle 724 on Page 19**



**The "Safari" is the first battery-operated television set to reach the market.** This truly is a light-weight, miniaturized step forward in the television industry.

Philco's advanced research and engineering puts television on a "view as you go" basis. Judson L. Thomson Mfg. Co. . . . pioneer in rivets and riveting machines since 1885 . . . salutes one of its best known customers for this notable achievement.

**Why use Thomson Rivets?** Value analysis proves that rivets belong in product-improvement and cost-reduction programs. No other permanent fastening method can match the combination of fastening strength, assembly speed and inspection ease inherent in riveting. From first cost to last, it rates first consideration.

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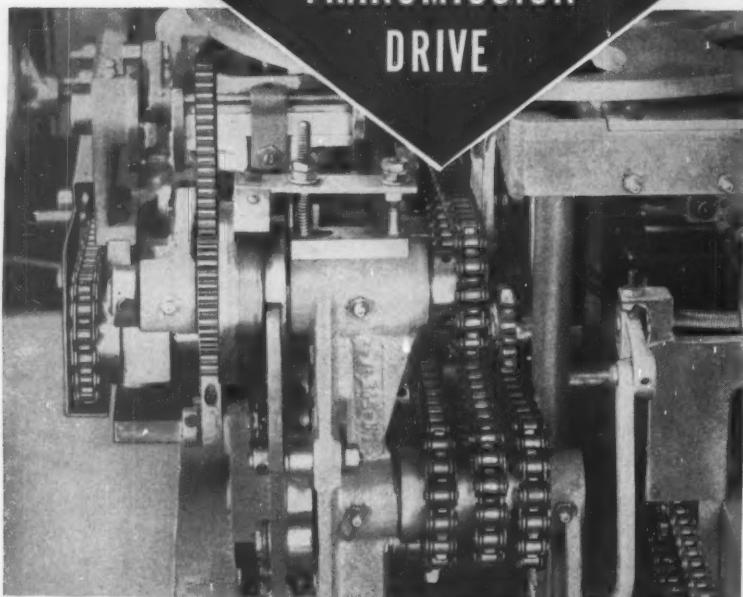


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## HELPFUL LITERATURE

### Bearing Units

Bulletin BU-103-A provides information on pillow blocks, flange blocks, adapter bearings, and take-up units. Catalog presents complete specifications, comparison charts, and load-rating charts. 20 pages. Browning Mfg. Co., Maysville, Ky.

Circle 725 on Page 19

### Industrial Packings

Revised catalog and price list FF-1059 offers extensive information on 14 types of Palmetto fabric, foil, plastic, and filament packings. Packings are available in nine constructions, illustrated in cutaway drawings. General data lists details on composition, application, service information and temperature limits for each packing. Also included are tables of sizes, lengths, weights, and prices. 8 pages. Greene, Tweed & Co., North Wales, Pa.

Circle 726 on Page 19

### Filter Elements

Folder on pressure-lock filter elements describes a new type of hydraulic and pneumatic filter element free of built-in contaminants and light in weight. Specifications for five types of elements covering rated flow capacities of 0.5, 3, 6, 12, and 24 gpm, plus details on degree of filtration, temperature range, construction materials, fluids, and minimum collapse pressure are included. 4 pages. Puro-Filter Products Inc., Dept. 132, Rahway, N. J.

Circle 727 on Page 19

### Mechanical Seals

New design-data folder includes two nomograms to facilitate the determination of frictional heat and power absorption for rotating mechanical seals. In addition, maximum permissible shaft speeds for rotating spring-type seals are given in chart form. Also, PV ratings for type RR Sealol-Flexibox seals are incorporated in Folder RA 2270. 4 pages. Sealol Corp., 231 Post Rd., Providence 5, R. I.

Circle 728 on Page 19

### DC Power Supplies

New catalog contains complete specification data for 75 direct-current power supplies in standard line. Power-supply selection chart permits the user to select output requirements and turn to complete data for supplies that fulfill his requirements. 16 pages. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.

Circle 729 on Page 19

### Speed Reducer

Brochure 5-250 illustrates and describes new speed reducer designed to accept NEMA-C face-mounted motors,  $\frac{1}{8}$  to 5 hp. Gear ratios range from 4:1 to 90:1. Tables give specifications, ratings, and dimensions, with or without motor. 6 pages. Janette Electric Mfg. Co., 8350 N. Lehigh, Morton Grove, Ill.

Circle 730 on Page 19



### **These names prevent misreading of your sealing specs**

These are not ordinary brand names. They were coined to help specifiers positively and conveniently identify the intent of sealing design. They prevent misinterpretation of packing specifications.

Each name stands for a basic composition of packing materials (available in various grades) with controlled properties from lot to lot produced. Each name certifies to characteristics and performance values corresponding to the general SAE-ASTM classifications.

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Circle 523 on Page 19

LUDLOW 3-3330



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possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation for the concept of value analysis—all are part of the Hassall service to you.

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### HELPFUL LITERATURE

#### Strain Gages

Product Bulletin BN-100 describes Series DA-100 semiconductor strain gages. Principle employed in these gages, the piezoresistance effect, is discussed in detail. Applications, properties, and temperatures are discussed, with particular attention given to DA-101, first unit of the series. 4 pages. Kulite-Bytrex Corp., 50 Hunt St., Newton 58, Mass.

**Circle 731 on Page 19**

#### Solenoids, Selectors, Motors

Bulletin A-1259, illustrated with line drawings, charts, photographs, and circuit diagrams, contains specific physical, performance, and environmental data on more than 250 different models of rotary solenoids, selectors, and Syncrametal stepping motors. Bulletin also supplies information on how to use this data to select the proper units for any application. 8 pages. G. H. Leland Inc., 123 Webster St., Dayton 2, Ohio.

**Circle 732 on Page 19**

#### Fasteners for Aluminum

Form 802-20-3 technical handbook, "Screw Fastening of Aluminum," covers the various types of standard and special fasteners and fastening systems used to join aluminum assemblies. Text is supplemented by 38 illustrations and 12 tables. It includes a list of manufacturers of special screw fasteners, and recommended hole sizes for various types of self-tapping screws in sheet aluminum and other materials. 48 pages. Reynolds Metals Co., PRD-32, Richmond 18, Va.

**Circle 733 on Page 19**

#### Electronic Products

Designated Bulletin AD-169, new catalog outlines specific mechanical, electrical, and environmental design characteristics of Chemelec Teflon, nylon, Kel-F, Delrin, and other plastic electronic components. Comprehensive drawings, illustrations, and tables are furnished for the various components. Bulletin also contains several basic engineering drawings of Chemelec stand-off and feed-through insulators drawn on tracing paper, for use in requesting product information. 24 pages. Garlock Packing Co., 443 Main St., Palmyra, N.Y.

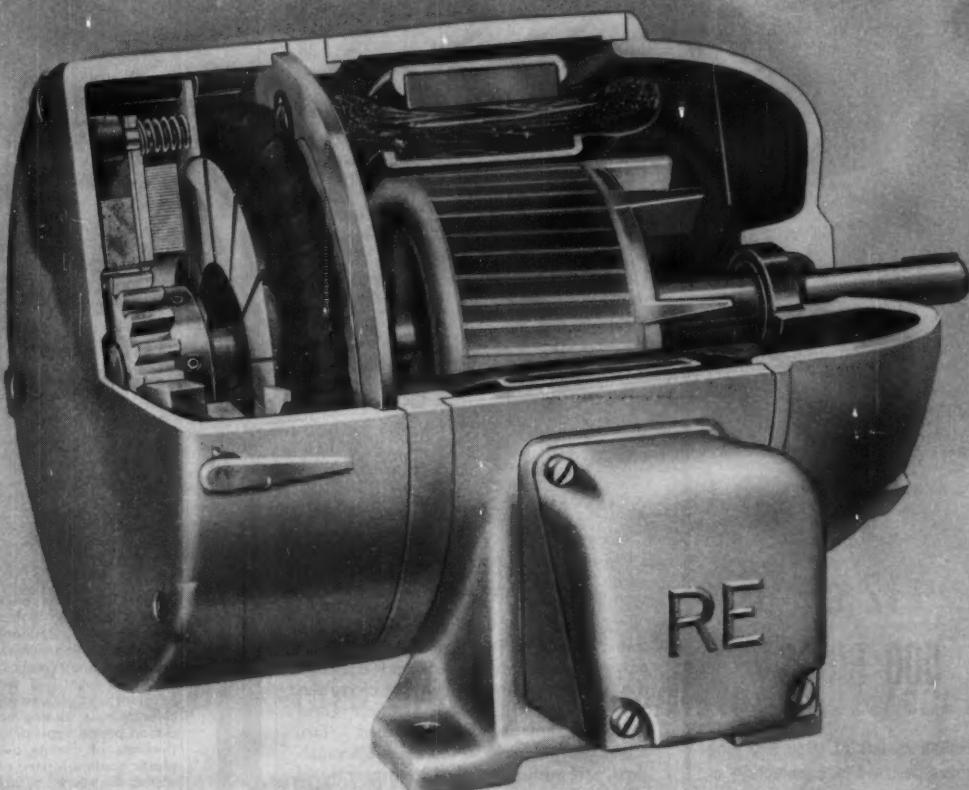
**Circle 734 on Page 19**

#### Flexible Couplings

Revised Bulletin 5103 covers complete line of Sure-Flex flexible couplings, including Junior couplings with flanges of zinc alloy AG40A, and large-size bushed couplings fitted with Sure-Grip interchangeable, QD-type tapered bushings. Engineering data is also given on spacer couplings with drop-center sleeves and on the use of Sure-Flex couplings with a floating shaft to connect two shafts that cannot be brought close enough together to be connected by a single coupling. 10 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

**Circle 735 on Page 19**

**REULAND MOTORS**



## **Reuland motor-and-magnetic-brake package**

*...complete from one dependable source!*

Reuland manufactures its own magnetic brakes, as well as electric motors, and offers the most versatile selection of tailored-to-your-equipment *brakemotor* packages available anywhere. Reuland's many hundreds of combinations of H.P., speed, special drive motors and brake sizes, provide an almost unlimited coverage of O.E.M. and user requirements!

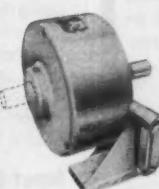
So, whatever your *brakemotor* needs may be, standard or special, let Reuland supply the complete answer in one, compact, smartly-designed power package. One source of supply for brake and motor saves time for your Engineering and Purchasing Departments . . . one nameplate establishes dependable, nationwide service responsibility!

*Refer to Sweet's Product Design, Section 5-a*

**MODERN POWER FOR MODERN-DAY PRODUCTS**

*... all in lightweight, cool-running aluminum frames!*

# **REULAND MOTORS**



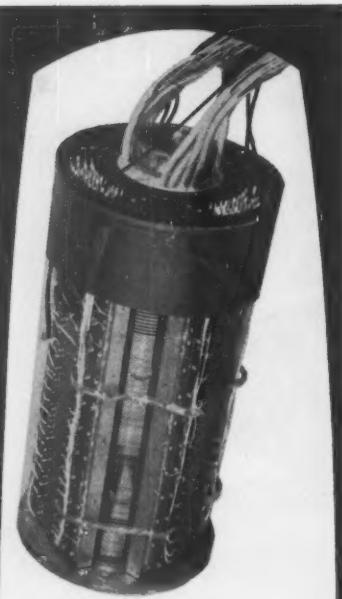
**BRAKES AVAILABLE IN ALL  
3 MOUNTINGS . . . FULFILLS  
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1. Direct endbell type for mounting over motor's shaft.
2. Foot mounted, for mounting over existing shaft.
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  - Wide Range of Ratings

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Circle 526 on Page 19

**HELPFUL LITERATURE**

**Electrical Connectors**

Bulletin B77 describes how heat and pressure are utilized to embed an entire connector assembly in a proper jacketing material to produce a homogenous continuity. Bulletin also describes some of the advantages of integrated connectors. Special designs for special applications are illustrated and identified, and standard in-stock styles are shown and described. 4 pages. Joy Mfg. Co., Electrical Products Div., 1201 Macklind Ave., St. Louis, Mo.

Circle 736 on Page 19

**Shaded-Pole Motors**

Technical Bulletin GED-3876 discusses features and points out basic advantages of new 33-frame Unitized motors. Bulletin describes electrical performance and dimensions, two basic versions, and applications for the motors in ratings of 1 through 20 mph. Tentative selection guide is included. Charts indicate relative sound level, sound frequency, wear-friction, and temperature effect on starting. 4 pages. General Electric Co., Schenectady 5, N. Y.

Circle 737 on Page 19

**Surface Alloying**

Chromallizing, a method of surface alloying which improves heat, wear, and corrosion resistance of metals and refractories, is the subject of Bulletin 40, "Designing for Chromallizing." Illustrated bulletin lists "dos and don'ts" for parts to be Chromallized, and drawings show proper radii and blending of corners to ensure smooth, finished surfaces. Good thread design is also illustrated. Two schematic diagrams compare a Chromallized part with one coated by conventional means. 2 pages. Chromalloy Corp., 452 Tarrytown Rd., White Plains, N. Y.

Circle 738 on Page 19

**Reinforced Plastic**

High-strength reinforced phenolic laminate, TRC-X, withstands temperatures in 1000-F range without blistering or delaminating. Interim bulletin gives temperature versus time data on flexural strength, flexural modulus, tensile strength, and edgewise compression. Information on thermal expansion, thermal conductivity, and specific heat is also included. 2 pages. Riverside Plastics Corp., 220 Miller Rd., Hicksville, N. Y.

Circle 739 on Page 19

**Input-Output Typewriter**

Bulletin IP-01 describes Codewriter, an electronic unit for data-processing and data-handling systems. Input model, output model, and combination input-output unit are included. Typical application in a process-control computer system is presented in flow-chart form. Also illustrated are a circuit diagram and keyboard chart. 4 pages. Royal McBee Corp., Industrial Products Div., 740 N. Main St., West Hartford 17, Conn.

Circle 740 on Page 19

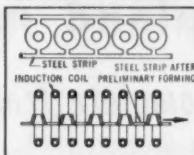
**TYPICAL INDUCTION  
HEATING APPLICATIONS**

**PLASTIC COATING  
OF TOOL HANDLES**



A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

**FORMING OF METAL STRIP  
FACILITATED BY  
PROGRESSIVE ANNEALING**

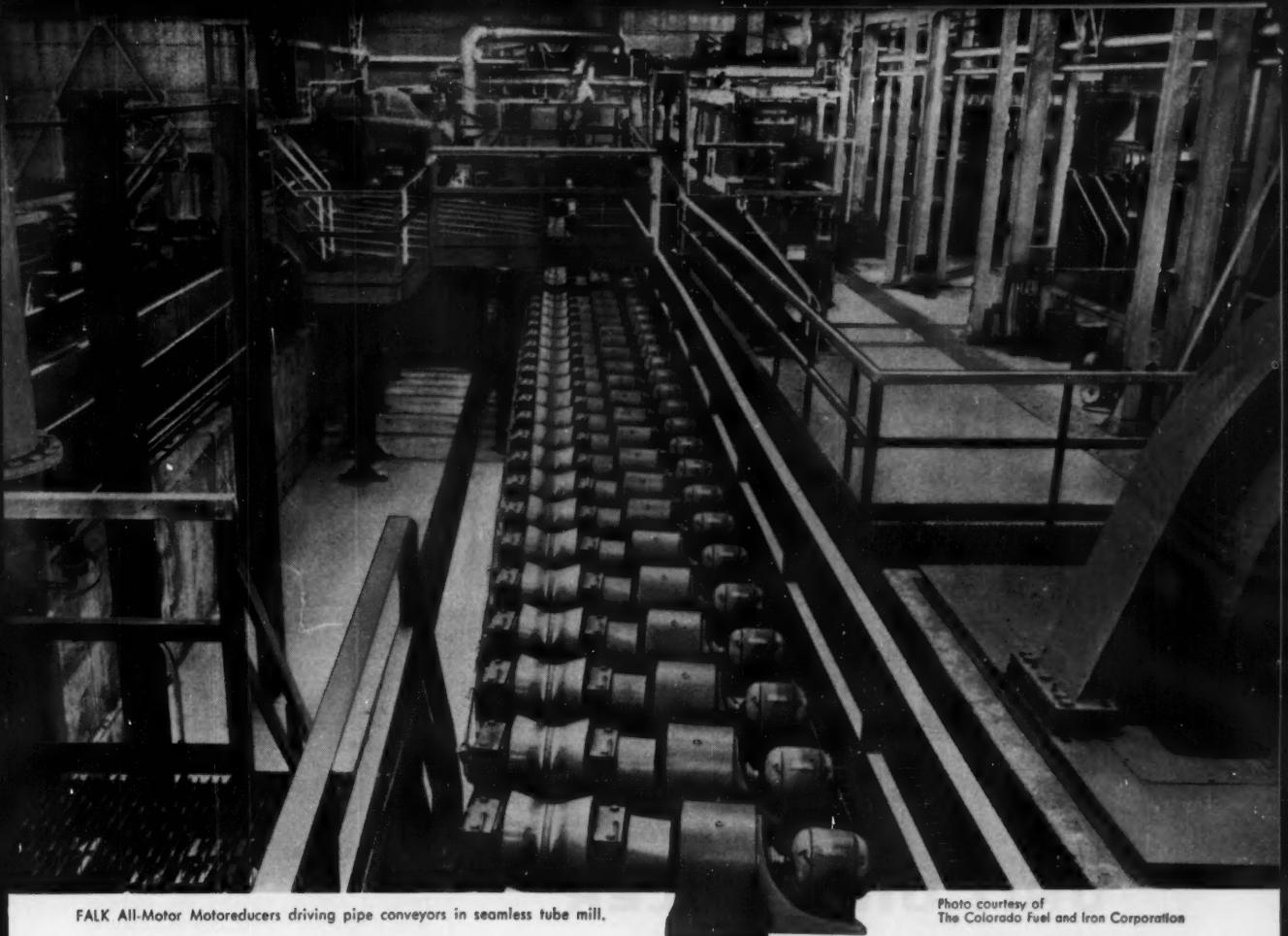


Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

**WRITE FOR NEW LEPEL CATALOG**  
Electronic Tube Generators from 1 Kw to 100 Kw.  
Spark Gap Converters from 2 Kw to 30 Kw.

**Lepel HIGH FREQUENCY  
LABORATORIES, INC.**  
55th ST. & 37th AVE., WOODSIDE 77, N.Y.

Circle 527 on Page 19



FALK All-Motor Motoreducers driving pipe conveyors in seamless tube mill.

Photo courtesy of  
The Colorado Fuel and Iron Corporation

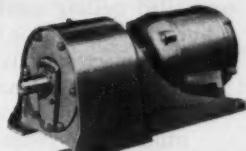
## You get these "extras" when you buy FALK all-steel Motoreducers

- Freedom from damaged housings.** The exclusive FALK all-steel construction gives full protection from cracked housings or torn-off feet...plus twice the ability of cast iron to maintain vital alignment.
- Inherently stronger gear teeth.** By AGMA standards, Falk extra-depth, high pressure angle helical gears are inherently stronger than ordinary helical teeth, thus assuring reliable operation and longer gear life.
- Highest known gear efficiency**—98½% per gear mesh under full load! This means maximum productive work for your power dollar.
- Longer service life**...advanced FALK design makes it possible to machine both bores for each shaft assembly at one time, thus eliminating possible accumulation of tolerances that occurs when individually machined parts are assembled. The result—better alignment of revolving elements that permits units to transmit rated capacity longer.
- Standard units to fit your needs.** Integral and All-Motor® Motoreducers are available in horizontal, vertical and right angle types...a type for every use.

Units are available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Prompt delivery from factory, warehouse or distributor stocks. Ask your FALK Representative or Authorized FALK Distributor for Bulletin 3100.

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Circle 528 on Page 19



THE FALK ALL-MOTOR®  
MOTOREDUCER  
the original All-Motor unit  
(Shown) Horizontal concentric model. Also available in right angle and vertical types.



THE ALL-STEEL FALK®  
SHAFT MOUNTED DRIVE  
Proved best for the countless  
industrial applications where a  
reducing unit mounting directly  
on shaft of the driven machine is  
indicated.

Units from 1/2 to 50 hp. Ratios  
—4:1, 14:1 or 24:1. Torque  
capacity up to 41,000 lb-in (in  
standard units). Prompt ship-  
ment from stock. For details,  
ask for Bulletin 7100.

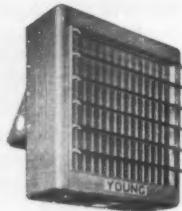
**FALK**  
...a good name  
in industry



## new automatic skin-milling machine

# COOLED by *Young* UNIT OIL COOLER

Metal coverings for modern supersonic aircraft and missiles are skin thin. Minute ripples must be removed to prevent turbulence in high speed flight. The above magnetic tape controlled milling machine accurately performs this task automatically. This efficient operation is cooled by an electronically controlled power package equipped with a Young OH-19 Unit Oil Cooler. The Young high-performance heat transfer unit serves the dual purpose of cooling oil and utilizing the "waste heat" to warm the interior of the building.



Patented Young Turbulator increases heat transfer 100%. Formed from a one-piece metal strip, the Young Turbulator breaks up fluid flow so that the fluid is constantly wiping tube surface for maximum heat transfer.

### for efficient Oil-to-Air Cooling select Young Type "OH" Unit OIL COOLERS

The cooling core of the Type "OH" Unit Oil Cooler is constructed of non-ferrous fins mechanically bonded to seamless tubes for maximum efficiency. Tubes are joined to steel headers by a special process which eliminates leaks and provides greater strength to the entire cooling element. Casings are of heavy gauge steel reinforced for strength and rigidity.

**Write Dept. 300-C for Catalog No. 3558 Type "OH" Unit Oil Coolers**

Specially practical for cooling lube oil where water is at a premium, and/or waste heat can be used to warm room interiors.



**YOUNG RADIATOR COMPANY**

General Offices: Racine, Wisconsin

Plants at: Racine, Wisconsin and Mattoon, Illinois

### HELPFUL LITERATURE

#### Epoxy Resins

"Data for Industry," No. 1, describes three new epoxy resins which display novel structure, reactivity, and curing characteristics. Booklet deals with physical properties of Oxiron 2000 series and tells how these resins differ from conventional epoxies. Tables present physical and mechanical properties of cured and uncured resins, and ten graphs illustrate such properties as heat-distortion points, exothermic data, and molecular structure. 24 pages. Food Machinery & Chemical Corp., Epoxy Dept., 161 E. 42nd St., New York 17, N. Y.

**Circle 741 on Page 19**

#### Numerical Control

Numerical control in machining operations is described in Booklet B 5917. Containing basic information and approximate costs of getting into tape-controlled operations, book is divided into four sections: Fundamentals of numerical control; how different types of numerical control operate what Numera-Trol is; and questions and answers. 20 pages. Ex-Cell-O Corp., 1200 Oakman Blvd., Detroit 32, Mich.

**Circle 742 on Page 19**

#### Investment Casting

Brochure on the latest methods of investment casting explains the ceramic-shell investment-casting process. Illustrations show the entire process, from making the die and pattern to finishing. 20 pages. Hitchiner Mfg. Co. Inc., Milford 30, N. H.

**Circle 743 on Page 19**

#### Plastic Properties Calculator

New sliding calculator is available for finding the properties of the major types of plastics. It can also be used to determine which plastic has the properties best suited to a specific design or engineering problem. Calculator, designed in three colors, is about 7 in. wide and 10 in. high. Request on company letterhead from Monsanto Chemical Co., Plastics Div., Dept. 1722, Springfield 2, Mass.

#### Miniature Bearings

"Design and Purchasing Manual" on miniature and instrument ball bearings contains complete specifications on 370 standard bearings from 1/10 to 5/8 in. OD, as well as 22 engineering bulletins discussing factors in bearing life and operation. Manual contains essential information on testing, packaging, marking, correct procedures in ordering, and data on radial play, runout, and other technical considerations. A load nomograph in engineering-data section assists the designer in selecting bearings to suit life and load requirements. Additional information covers corrosion resistance, duplexing, lubrication, storage, and materials. 140 pages. Request on company letterhead from New Hampshire Ball Bearings Inc., Route 202, Peterborough, N. H.

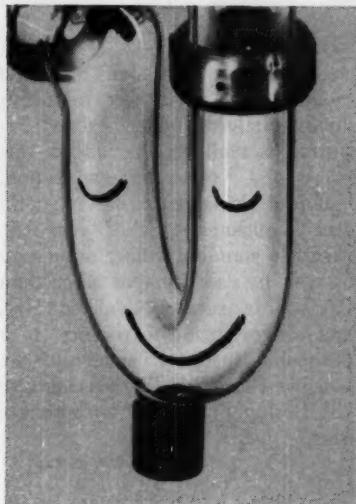
# THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS



FROM CORNING

## A GOOD OLD-FASHIONED GUARANTEE AGAINST DRAINLINE CORROSION



It's the sort of thing that drives stolid corporation lawyers to scribing frantic memos, but we are offering a hard-rock guarantee against corrosion and leakage with our PYREX® lifetime drainline.

We use "guarantee" in the old, unweaselworded sense of the term: we replace any piping material damaged due to corrosion and/or leakage during the life of the building.

We insert just one escape clause: we cannot tolerate, nor can the drainline, massive volumes of hydrofluoric acid, hot alkalies or hot phosphoric acid. Even here, check with us just to make sure. Anything else goes—acids, alkalies, or whathaveyou.

So throw away those drip buckets, stop giving the "new man" the desk under the leaking joint . . . the next time you install or replace a drainline, make sure it bears the "PYREX" trademark.

Look at the coupon.

*Longevity under adverse, even hostile, conditions is a well-known trait of Corning glasses . . . a fact to consider, even ponder, when you run up against materials with but a modicum of stamina.*

## WHO WANTS TO TRANSMIT 80% to 90% OF INFRARED THROUGH A WINDOW AT 900° C. OR IN THE PRESENCE OF CORROSIVES?

Ours not to reason why. Ours only to inform you that there are two VYCOR® brand glasses that service both conditions admirably.

There is VYCOR No. 7905 glass. A sheet of this 2 mm. in thickness will transmit

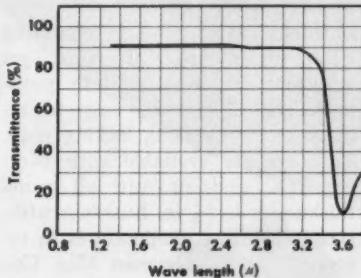
90% of the wave lengths up to and including 3.0 microns. A  $\frac{1}{8}$  in. thickness will transmit 80% of a wave 2.75 microns across.

Then there is VYCOR No. 7950 glass. It is stained red. It does like work with infrared, but absorbs most of the visible light waves from a tungsten filament humming away at 2700°K.

Both glasses function continuously in the manners stated at 900°C. even in the presence of corrosives and will take intermittent jolts into the 1200°C. plus region without damage.

Both will take a sudden thermal shock from these empyreal heights right down to 0°C.

INFRARED TRANSMISSION FOR GLASS NO. 7905  
(2 mm. Thickness)

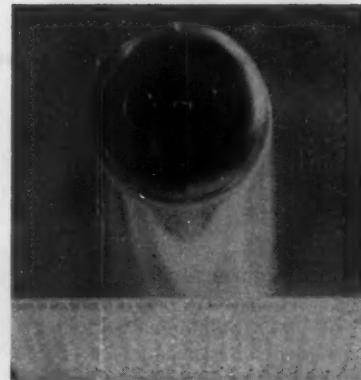


Both actually increase in mechanical strength as the temperature goes up. Odd, what?

There's much more you ought to know about these and the other VYCOR brand glasses, but we'd like to find out just how many and what kind of people are interested in such matters, so we've put the rest of the data away in a bulletin which you may have in exchange for the information asked for in the coupon.

## silent light (fluorescent)

Making an electroencephalogram under fluorescent lights can be as nightmarish as listening to Leonard Bernstein conduct



in a subway. The same holds true for any sensitive electronic device that can pick up unwanted noise from a hot tube.

From now on, anyone seeing unworthy blips or blurs on his trace of a monkey's alpha waves might find our new PYREX brand E-C No. 70 panel helpful.

E-C No. 70 is a glass panel with an electroconductive coating fused to one side, a coating grounded with a  $\frac{1}{4}$ " strip of silver running around the perimeter of the panel. The coating is "tuned" to pick up and throw to the ground all radiation from 0.018 to 25 mc.

Add a simple line filter and a GBM ballast to your fixture, and all that comes out is clear, clean, quiet light, free from both radiated and conducted radio noise.

E-C No. 70 is optically designed to give low brightness to the light it lets through, this being 70 to 78% of the light emitted by the tubes.

E-C No. 70 is made of borosilicate glass, so it takes a goodly amount of corrosive atmosphere and thermal shock in stride.

E-C No. 70 meets all the many requirements of MIL-I-1690A—ships.

E-C No. 70 may be had in panels up to 28" in width, up to 48" in length.

Still more may be learned about E-C No. 70 by posting the coupon.



CORNING MEANS RESEARCH IN GLASS  
CORNING GLASS WORKS, 52 Crystal St., Corning, N. Y.

Please send me:  PE-30, PYREX lifetime drainline  
 B-91, VYCOR Industrial Glassware  
 A2, PYREX E-C No. 70 Glass Panels.

Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

# New Parts and Materials

Use Yellow Card, page 19, to obtain more information

## Precision Switch

weighs less than 1/28 oz

Klixon AT1-1 precision switch, with envelope dimensions of 0.32 in. diam by 0.44 in. long, weighs less than 1/28 oz. Subminiature switch is designed for applications which require a true hermetically sealed unit of the smallest and lightest configuration possible, combined with high reliability, for aircraft,



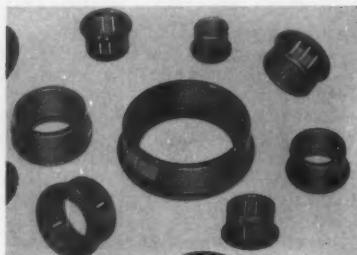
missile, and electronic uses. Terminals are brought out through a fused-glass seal to make assembly completely environment-free. Casting is stainless steel. Switch is filled with a dry, inert gas to ensure reliability for dry-circuit applications. Current capacity is 3 amp, 28 v dc, resistive. Ambient temperature range is -65 to +275 F. Unit resists 40 g vibration and 100 g shock. Texas Instruments Inc., Metals & Controls Div., Spencer Products Group, 34 Forest St., Attleboro, Mass.

Circle 744 on Page 19

## Nylon Snap Bushings

for use in mounting holes from  $\frac{3}{8}$  to  $1\frac{1}{2}$  in. diam.

Nylon Heyco snap bushings are suitable for use in mounting holes from  $\frac{3}{8}$  to  $1\frac{1}{2}$  in. diam. Material provides complete insulation and mechanical protection for electrical wire and cable, tubing and hose, rope and cable, and can be used



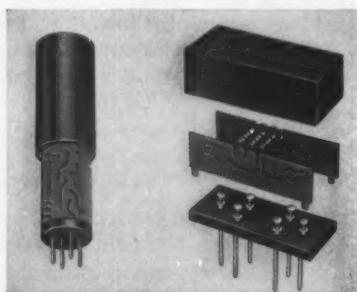
as a bearing for moving parts. Bushings are installed in mounting holes under finger pressure, yet withstand at least a 35-lb push-back test. They are easy to remove by compressing locking steps. Bushings are available with varying IDs, and fit into all panel thicknesses to  $\frac{1}{8}$  in. Bushings withstand operating temperatures in excess of 150 C. Heyman Mfg. Co., 100 Michigan Ave., Kenilworth, N. J.

Circle 745 on Page 19

## Printed-Circuit Boards

miniature units are custom-molded

Using new epoxy molding compounds, miniature molded printed-circuit boards provide high-temperature resistance, high dielectric characteristics, low moisture absorption, high dimensional stability, good mechanical strength, and excellent chemical resistance. Circuit canals are molded in the board in accordance with circuit design;



component lead holes are also molded in. Circuits are high-conductivity silver, and gold-plated circuitry is available for added tarnish and corrosion protection. Standard thickness is 0.05 in., with other thicknesses also available. Black is standard color; other colors can be used. Shapes other than flat boards, such as oval, concave, and convex, made to conform to a particular space or assembly, are possible. Plastronic Engineering Co., 721 Boston Post Rd., Marlborough, Mass.

Circle 746 on Page 19

## Gear Motor

subfractional-hp unit is worm-drive type

Type WGM subfractional-horsepower, worm-drive gear motor offers extremely quiet operation at



low cost. Suggested applications include motorized business machines, revolving displays, appliances, vending machines, remote television tuning, motorized valves, and instruments. Motor is two-pole, shaded-pole, ac induction type, available in voltages from 6 to 220 v, 50 or 60 cycle. It is designed for continuous or intermittent operation. Gear reducer is totally enclosed and pre-lubricated, has zinc die-cast gear housing with stamped steel or aluminum cover. Output speeds range



## DO YOUR MOLDED COMPONENTS GIVE YOU HEADACHES?

Compound dilemmas? Should it be Neoprene . . . Buna-N . . . VITON® . . . Silicon or Polyacrylic? How about temperature . . . below zero or sizzling? Unusual pressure conditions? . . . or perhaps a highly destructive hydraulic fluid?

If compound . . . temperature . . . pressure or the medium bring unusual problems to your drawing board call on IPC. Our "custom" approach to *your* application is strengthened by broad experience in the use of materials and molding techniques.

Strict attention to detail is an IPC hallmark. We welcome problem solving. Ask your IPC representative to show you samples of some unusual headaches we've cured.



OIL SEALS / PACKINGS / PRECISION MOLDING Custom designed for your application.

\*Trademark E.I. DuPont deNemours & Co.

**INTERNATIONAL PACKINGS CORPORATION**

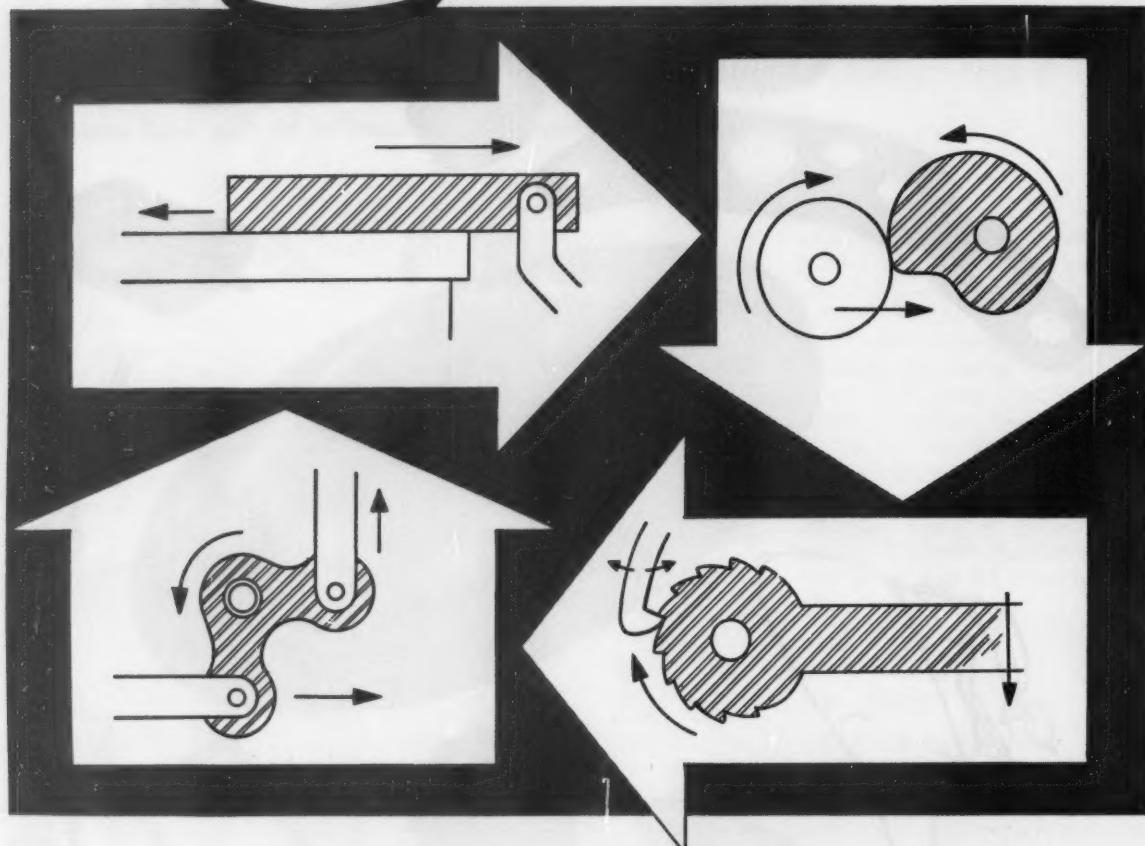
Bristol, New Hampshire

© IPC

P-2



# METALS...



## ...for Design Wearability

If it slides on a surface . . . rolls on a shaft . . . makes interrupted contact . . . turns on a pivot . . . or performs any other function involving wear . . . you can rely on V-R metals to help solve your wear-part problems.

Extreme resistance to wear is just one of the valuable characteristics of metals that V-R makes available to the designer. It will also pay you to contact V-R whenever parts of your equipment require corrosion resistance . . . high density . . . stability at extreme temperatures . . . rigidity under a given load . . . good surface finish . . . and low coefficient of expansion for greater dimensional uniformity.

These properties can be produced in various combinations in sintered or alloyed metals to fill your specific needs . . . just send us the details of your requirements.



### VASCOLOY®-RAMET

CREATING THE METALS THAT SHAPE THE FUTURE

#### NEW PARTS AND MATERIALS

from  $\frac{1}{2}$  to 300 rpm, and output torque is as high as 50 lb-in. at  $\frac{1}{2}$  rpm. Available output shaft diameters are  $\frac{3}{16}$ ,  $\frac{1}{4}$ ,  $\frac{5}{16}$ , and  $\frac{3}{8}$  in. Molon Motor & Coil Corp., 3739 Industrial Ave., Rolling Meadows, Ill.

Circle 747 on Page 19

#### Panel Meter

has printed-circuit movement



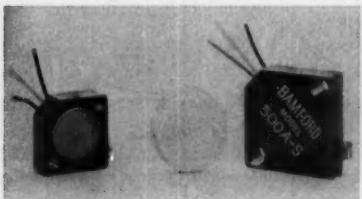
New  $3\frac{1}{2}$ -in. Series S-35 panel meter is contained in a front-scale housing only  $\frac{1}{2}$  in. thick. Two small screws projecting from housing serve as mounting lugs and electrical connectors. Movement consists of a light-weight disc on which are printed four coils, nylon pointer, and thin ring magnet assembly. Performance is unaffected by external magnetic influences. Design affords protection against effects of electrical overload and mechanical shock. Interlab Inc., 437 Fifth Ave., New York 16, N. Y.

Circle 748 on Page 19

#### Trimming Potentiometers

subminiature units  
have high power rating

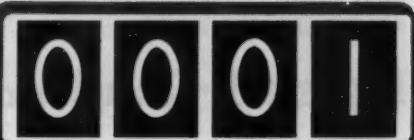
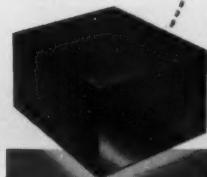
Series 375 and 500 subminiature potentiometers provide small size and light weight for high resolution in instruments and systems for aircraft and missile applications. They also provide high inherent stability in ground instruments and systems. Units have high power rating, superior resolution, dual contact wiper, moisture resistance, Teflon-insulated lead wires, precision-machined aluminum case, and 25-turn O-ring



#### The NEW Series BH100

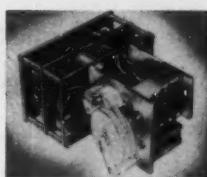
# MILLI-V-METER\*

DIGITAL  
READOUT



ACCURACY  
0.1%

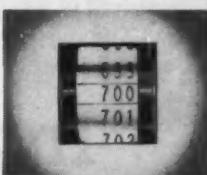
THE INSTRUMENT  
with the  
TAPE-SLIDEWIRE



ALL INCLUSIVE — With Zener  
reference, power supply, am-  
plifier, servo motor, 144" tape-  
slidewire.



TAPE-SLIDEWIRE — Mounted  
on side-by-side spools, slide-  
wire is embedded in edge of  
tape, punched for sprocket  
drive.



PRINTED READOUT — Calibra-  
tion printed on tape available  
to measure steady-state condi-  
tions or where input deviates  
more than 13%.

Every scale division is  
a calibrated point.

100 calibrated points  
per foot of slidewire length.

Slidewires  
up to 12 feet long.

LINEAR, PARABOLIC, LOGARITHMIC  
FUNCTIONS ARE DISPLAYED IN DIRECT  
DIGITAL RELATION

\* TRADE MARK



Sales-Engineering Offices:

ATLANTA, GA., COMPTON, CAL., DAYTON, OHIO, VALLEY STREAM, L. I., N. Y., WICHITA, KAN.  
TORONTO, ONT. (George Keil Ltd.) MITCHAM, SURREY, ENGLAND (Bryans Aeroequipment Ltd.)

3479 West Vickery Blvd. • Fort Worth 7, Texas

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MITCHEM, SURREY, ENGLAND (Bryans Aeroequipment Ltd.)

Full information is available for the asking!

**B & H INSTRUMENT  
CO., INC.**



## Ingersoll-Rand solves pumping headaches . . .



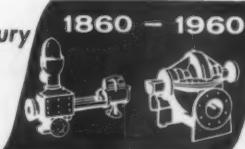
You tell Ingersoll-Rand the liquid to be handled, the flow, temperature, pressure requirements and how you want to mount the pump — and I-R will furnish you with a unit to meet your exact needs.

In 100 years of pump manufacture, Ingersoll-Rand has solved many problems for machinery builders. For an economical solution to your liquid moving problems, call for the pump specialist at your nearest I-R branch office — or write direct to our New York headquarters. If we can't meet your requirements from our many standard models, we will engineer a unit just for you.



a century

1860 - 1960



of pump progress

from the leading manufacturer . . .

# Ingersoll-Rand

83A9

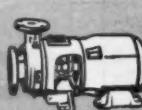
11 Broadway, New York 4, N. Y.

Immersion or sidewall  
units to 7½ HP for deliveries  
to 425 gpm, heads to 170 ft.

OTHER I-R PUMPS AVAILABLE



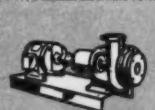
Self-priming pumps



Motorpumps



Horizontally split pumps



Cradle Mounted pumps

#### NEW PARTS AND MATERIALS

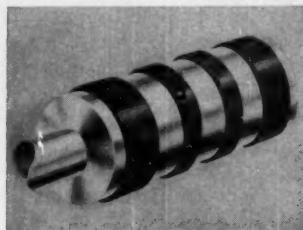
sealed adjustment. Extremely accurate and reliable, they meet or surpass requirements of MIL specifications. Power ratings are 1 and 2 w, respectively. Dimensions are 0.375 x 0.375 x 0.175 in. for Series 375 and 0.500 x 0.500 x 0.175 in. for Series 500. Bamford Corp., 11167 Tennessee Ave., Los Angeles 64, Calif.

Circle 749 on Page 19

#### Piston Rings

are filled-Teflon type

Filled-Teflon piston rings are suitable for nonlubricated service to seal reciprocating, oscillating, and rotary motion of both external and internal cylindrical surfaces against leakage of liquids or gases. Matched filled-Teflon rider rings are also



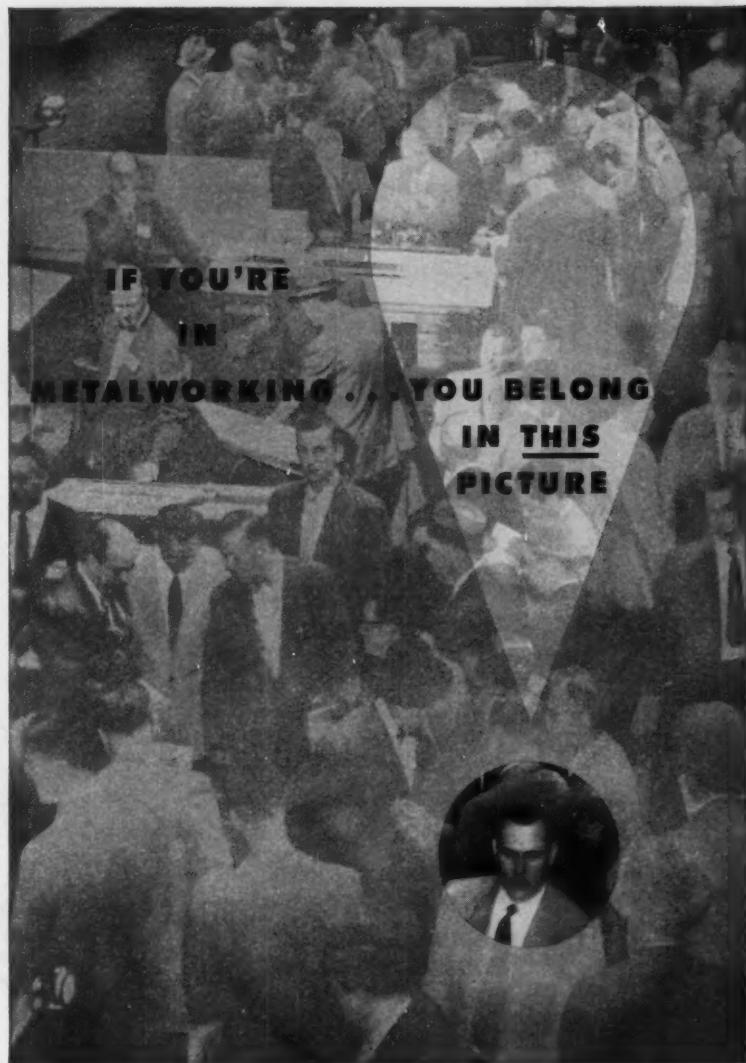
available for use in conjunction with the rings where long stroke or heavy pistons necessitate additional support. Rings are carbon-filled Teflon which exhibits a lower coefficient of friction than any other solid material. They have exceptional thermal stability and are suitable for continuous service in a temperature range from -420 to 500 F. Rings are tough, abrasion-resistant, and have ability to imbed hard foreign particles without adversely affecting cylinder life or ring itself. Rings are available in many different designs including butt joint, step joint, or solid design. Garlock Packing Co., 444 Main St., Palmyra, N. Y.

Circle 750 on Page 19

#### Flow-Control Valve

is linear through 15 turns

Model F4 micrometer flow-control valve is designed to overcome the disadvantages of low-flow adjustment and clogging of small passages inherent in needle valves. Screw adjustment of the length of the



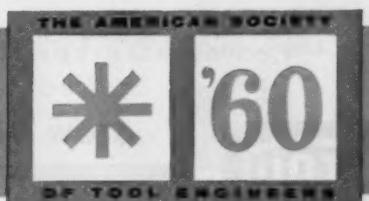
## 1960 TOOL SHOW and CONFERENCE

DETROIT ARTILLERY ARMORY  
APRIL 21ST THRU 28TH

The nation's foremost forum for the advancement of scientific knowledge in the field of tool engineering

for rapid registration forms write:

**AMERICAN SOCIETY  
OF TOOL ENGINEERS**  
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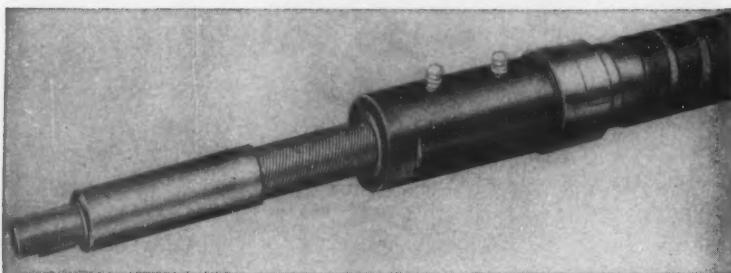


# STOW FLEXIBLE SHAFTING

## The Ideal PTO Drive



1 1/4" flexible shaft under tractor-trailer transmitting 10 HP.



1 1/4" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

### FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from  $\frac{1}{4}$  inch to  $1\frac{1}{4}$  inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems in advance. The know-how of 82 years' experience goes into every STOW flexible shaft!

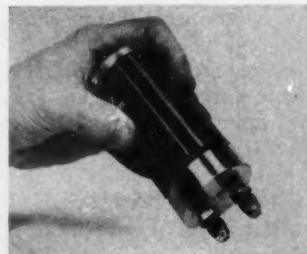
STOW flexible shafts are being used on trucks and tractor-trailers to:

- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.

- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

### NEW PARTS AND MATERIALS



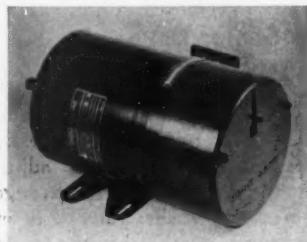
viscous passage is of micrometer precision. Rate of flow is increased linearly ten-fold through 15 turns. Flow passage area is constant, serving to reduce possibility of clogging, particularly at low-flow settings. Flow in the valve, using Univis 40 oil at a temperature of 115 F and a pressure drop of 100 psi, can be regulated from 10 cc/min to 100 cc/min through 15 turns, equivalent to about 6 cc/min per turn. Flow is further increased to 1150 cc/min through 9 more turns. Performance of the valve is equally good with other fluids and with gases. Applications include all industrial uses where needle valves are used for flow control. Valve is about 5 in. long and 2 in. in diam. Sanders Associates Inc., 95 Canal St., Nashua, N. H.

Circle 751 on Page 19

### AC Brake Motors

fractional-hp units provide positive stopping of loads

Form G fractional-horsepower, three-phase, ac brake motors in dripproof and totally enclosed, fan-cooled construction feature unified design which makes motor and brake an integral, one-piece unit. End shield of motor also serves as end shield of brake, providing compact size and neat appearance. Units are designed for such applications as overhead doors, cut-off mechanisms, index mechanisms, machine tools, conveyors, small elevators, and other devices where



### STOW MANUFACTURING CO.



11 Shear St.

Binghamton, New York

# Variable Speed Simplicity Economy



## REEVES vari-speed MOTOR PULLEY

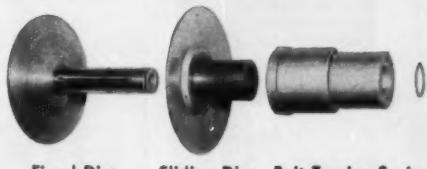
The obvious advantages you gain from this Reeves Motor Pulley design are accurate variable speed control, low cost operation, no problems.

It's as simple as this: There are two smooth-faced cone-shaped discs, one mounted in fixed position on the motor shaft, the other designed to slide laterally on the hub of the fixed disc. Belt tension spring automatically maintains pressure on the sliding disc for correct belt tension at all output speeds, while smooth, stepless speed changes are accomplished by adjusting the sliding motor base.

Disc Assemblies are available in nine sizes,  $\frac{1}{2}$  hp. through 15 hp. to fit either old or new NEMA motors. Speed ranges up to 4:1. Separately mounted countershaft assemblies are available to match any of your machine speed requirements. Your Reliance Sales Engineer has all the facts. Call him . . . or if you prefer, write for Bulletin No. GV-582-1.

G-1629

### ONLY 3 MAIN PARTS!



Fixed Disc      Sliding Disc      Belt Tension Spring



### ONE LUBRICATION POINT!

Reeves exclusive "Close Grooving" maintains a film of lubricant between hub length of fixed disc and bore of sliding disc . . . prevents sticking.

Product of the combined resources of  
Reliance Electric and Engineering Company and its Reeves and Master Divisions

**RELIANCE** ELECTRIC AND ENGINEERING CO.  
DEPT. 283A2, CLEVELAND 17, OHIO  
Canadian Division: Toronto, Ontario  
Sales Offices and Distributors in Principal Cities



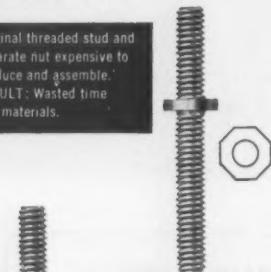
Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



**HOW HUBBELL  
COLD HEADING  
PRODUCES BETTER PARTS  
AT FASTER SPEEDS**

Optimum results aren't necessarily reached the first time a part is redesigned for cold heading. Careful re-examination by Hubbell engineers may suggest a new and more efficient redesign which will make a part even more economical. As in this Hubbell case history, design evolution produced a better end product with substantial savings in assembly costs.

Original threaded stud and separate nut expensive to produce and assemble.  
RESULT: Wasted time and materials.



Redesigned for cold heading, the stud and the nut section are combined.  
RESULT: Savings in production, labor and materials.

Redesigned again for cold heading... nut section removed and knurl section added. RESULT: Faster, easier assembly; greater product security.



*Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.*

See the Hubbell Fastener Catalog in Sweet's Product Design File 7/Hu

**HARVEY HUBBELL,  
INCORPORATED**  
Machine Screw Department  
Bridgeport 2, Connecticut

Circle 538 on Page 19

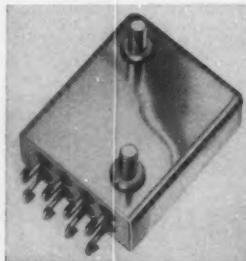
**NEW PARTS AND MATERIALS**

positive stopping or holding of loads is required. Magnetic brake is used to bring motor to rest and to hold load stationary when motor is not energized. It is spring-set and solenoid-released, and automatically sets should power fail. Ten-year lubrication without maintenance for normal service is provided. Brake motors are available in sizes from  $\frac{1}{4}$  through  $\frac{3}{4}$  hp. General Electric Co., Schenectady 5, N. Y.

Circle 752 on Page 19

**Latching Relay**

subminiature unit  
operates on 100 mw



BR-9 series 10-amp magnetic latching relay weighs approximately 1 oz, features minimum life expectancy of 100,000 cycles at 125 C, and operates on as little as 100 mw. Relay is shock-rated at 50 g for 11 millisecond, and 30 g vibration at 10 to 2000 cps. MIL-R-5757C and 25018 specifications are fully met. Unit is available in DPDT arrangement with maximum coil dissipation of 3 w. Babcock Relays Inc., 1640 Monrovia Ave., Costa Mesa, Calif.

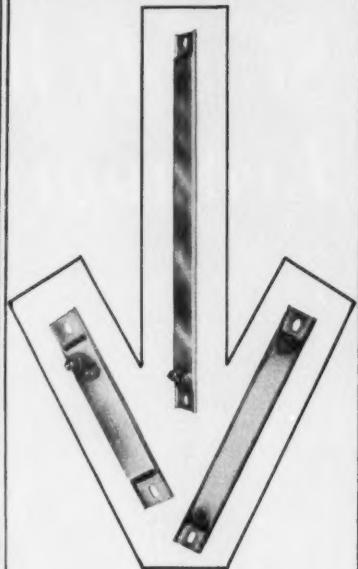
Circle 753 on Page 19

**Resistance Alloy Wire**

has ceramic and  
TFE insulation

Resistance wire coated with Ceron dual-layer, high-temperature insulation of ceramic and Teflon fluorocarbon, operates continuously at temperatures of 250 C, and up to 300 C for short periods. Combination of a ceramic undercoating with an overlay of Teflon imparts excellent mechanical and electrical properties, and offers excellent solvent and heat resistance. Insulation is available on DR, an iron-based alloy with a high resistivity

**ON THE SURFACE...**



**YOU CAN'T BEAT  
VULCAN STRIP  
HEATERS**

The surface we mean is *any* flat surface to which Vulcan Strip Heaters can be clamped — dies, platens, molds, etc. Vulcan Strip Heaters are also excellent as air heating sources for ovens, air ducts, dryers, etc. And these versatile heating elements can be formed into circles (one or two-piece) in radius of 5" or more.

Standard one-piece seamless sheaths are made in steel for sheath temperatures to 750°F; Chromalloy to 1200°F. Lengths are from 8" to 42½" (special, shorter or longer). Wattage ratings are from 150 to 1500 (or higher).

*Write for catalog and prices.*

**VULCAN**

*Versatility in Electric Heating*

VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 539 on Page 19

**TODAY AND TOMORROW**

**whatever may be your problems**

# BUNTING<sup>®</sup>

## BEARINGS *Supply the answers*

... Cast Bronze Alloys... Powdered Sintered Metals... Bearing Aluminum Alloys

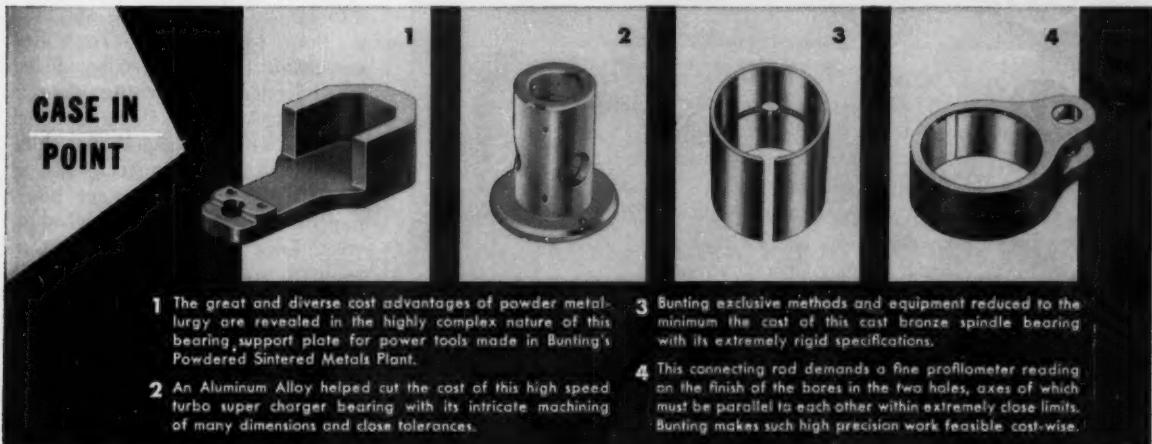
Why pay more for a bearing or part than you have to? Let Bunting help you get your requirements down on the lowest cost level compatible with adequate performance.

Today and tomorrow "the best" bearing means one that will do the job at the lowest possible cost. Let Bunting help you find the best bearing.

Bunting offers a highly competent designing, engineering and manufacturing facility operating in the field of bearings and special parts.

All modern proven materials are available, others are under study. Two plants with advanced equipment—of our own design—assure absolute production control and lowest manufacturing cost.

Let us re-examine your current bearing applications, or work with you on new requirements. Send in your prints for study and pricing. No cost nor obligation.



### CASE IN POINT

- 1 The great and diverse cost advantages of powder metallurgy are revealed in the highly complex nature of this bearing support plate for power tools made in Bunting's Powdered Sintered Metals Plant.
- 2 An Aluminum Alloy helped cut the cost of this high speed turbo super charger bearing with its intricate machining of many dimensions and close tolerances.
- 3 Bunting exclusive methods and equipment reduced to the minimum the cost of this cast bronze spindle bearing with its extremely rigid specifications.
- 4 This connecting rod demands a fine profilometer reading on the finish of the bores in the two holes, axes of which must be parallel to each other within extremely close limits. Bunting makes such high precision work feasible cost-wise.

**MACHINING SERVICE:** Emergency service machine shops in Bunting Branches are there to render immediate low cost service on bearings or parts needed for experiment or maintenance. Your local Bunting Distributor can arrange for such service.

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No. 46—TECHNOLOGY OF BUNTING BEARING ALUMINUM—A technical treatise on the composition and machining of Bearing Aluminum Bar Stock.



No. 1... ENGINEERING HANDBOOK OF POWDER METALLURGY—A comprehensive technical treatment of engineering and manufacturing of sintered metals, bearings and parts.



No. 159—GENERAL CATALOG—Complete listings of Cast Bronze and Sintered Bronze Stock Bearings and Bars and Bunting Bearing Aluminum Bars available from stocks of local distributors all over America.

**THE BUNTING Brass and Bronze Company • Toledo 1, Ohio • Phone EVERgreen 2-3451**

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE, SINTERED METALS OR ALUMINUM ALLOYS

## NEW PARTS AND MATERIALS

of 812 ohms per circular mil foot, as well as on several Nikrothal alloys, including standard 80/20 and 60/15 nickel-chromium alloys. Sizes from 0.001 to 0.0045-in. wire diam are currently available. Kanthal Corp., Amelia Place, Stamford, Conn.

Circle 754 on Page 19

## Swivel Lock

converts casters from swivel to rigid



Multiposition swivel lock is offered on heavy and extra-heavy-duty forged-steel casters with capacities to 3000 lb. Lock permits fingertip conversion of casters from swivel to rigid at any position. Any number of locking slots can be milled into caster yoke base at specified positions to provide controlled movement in any direction. Fixed to underside of attaching plate is a spring-loaded, finger-operated plunger which engages the slots. When retracted, plunger seats in a vertical notch in plunger housing to hold it clear of swiveling yoke. Lock can be used alone to facilitate steering over a prolonged straight course, or in conjunction with a wheel brake. Wheel types available include metal, molded plastic, Moldon rubber, semipneumatic, and polyurethane in diameters up to 12 in., and pneumatic rubber tires in diameters from 8 to 16 in. Hamilton Caster & Mfg. Co., Hamilton, Ohio.

Circle 755 on Page 19

## Air Cylinders

are double-end,  
stainless-steel units

Double-end rod stainless-steel air cylinders are 1-1/16-in bore, double-acting units available in stroke



## SCIENTIFIC MIXING...



symbol of controlled production



Only scientifically controlled production mixing can produce the full potential of a laboratory-developed formula as it pertains to an exacting rubber product. At PARCO, a dozen or more basic materials may be mixed together to produce a specific compound for an "O" Ring, a custom molding or for rubber to metal bonding. Every phase of this mixing process is under exacting laboratory control.



Each basic ingredient of the compound recipe is laboratory-analyzed before it is used. The amount of each ingredient in the compound recipe is carefully controlled by weight/measurement using laboratory techniques. Mixing time is pre-established by research. The finished mix is then laboratory tested to be sure it meets all predetermined qualifications prior to the next production process.



This is why, at PARCO, scientific mixing is a symbol of controlled production!

*Send today for your free PARCO Pic-O-Ring desk/wall chart. A must when "O" Rings are concerned.*



**PLASTIC AND RUBBER PRODUCTS COMPANY**

2100 Hyde Park Boulevard • Los Angeles 47, California

Circle 541 on Page 19

Cylinders need not  
be expendable



**With Extras . . . At No Extra Cost**

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

Specify the

**T-J Spacemaker**

**for longer, more efficient cylinder service**

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

**T-J**

**TOMKINS-JOHNSON**

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DISC BRAKES

THE CHOICE OF LEADING MOTOR MANUFACTURERS

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with this Kearney & Trecker  
Special Production Machine Tool**

This special "K & T" two-spindle, precision, production machine tool for the electric power industry mills both inside and outside radii of curved, alloy steel turbine blades in a single pass — at three times former conventionally tooled feed rates. A versatile 360° drum fixture handles 81 different blade sizes without overtravel on rapid stroke for extremely short cycle time . . . a function of Stearns Brakes on machinery for all industries. "K & T" engineers specified Stearns for this tough, rapid-cycle application due to previous experience . . . the efficiency, longer life, exclusive "Visi-Wear-Indicator," and ease of installation and maintenance — the only brakes where a screwdriver is a complete maintenance tool kit.

For solutions to YOUR brake and clutch problems, call the Stearns Representative in your vicinity. Or write, stating your specific requirements, directly to . . .



**NEW PARTS AND MATERIALS**



lengths through 18 in. Mirror-finish stainless-steel bodies and ground and polished stainless-steel rods, coupled with U-cup piston and piston-rod seals, provide long life. **Bimba Mfg. Co.**, 101 Main St., Monee, Ill.

**Circle 756 on Page 19**

**Pressure-Sensitive Adhesive**

bonds plastic insulations  
to wood, metal, fiberboard

Rez-N-Glue No. 298 is a cold-setting, pressure-sensitive adhesive formulated especially for bonding supported vinyl and polyethylene insulations to wood, metals, paper, and fiberboard. Light tan adhesive with thin-syrup viscosity will not stain or crystallize, and has a high resistance to ultraviolet light and heat. It is applied to clean, grease-free, rigid surface of vinyl or polyethylene materials, or to both surfaces of more porous materials. After sections are air dried for 2 to 30 min, they can be assembled by ordinary hand pressure. One gallon covers approximately 200 sq ft. Glue, with an oil-resistant, synthetic-rubber base, is supplied in quart, gallon, 5 gal, and 55-gal containers. **Schwartz Chemical Co., Inc.**, 50-01 Second St., Long Island City 1, N. Y.

**Circle 757 on Page 19**

**Thermocouple Glands**

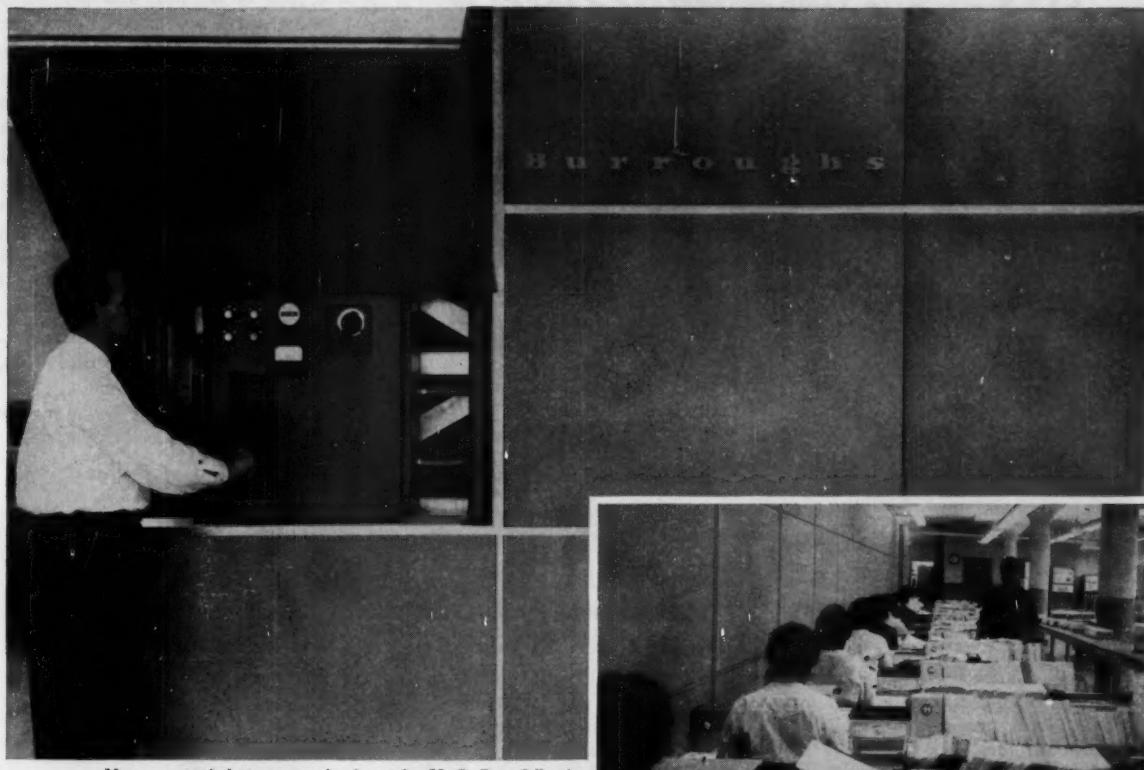
seal two or four 20 to 24-gage  
bare-wire thermocouples

Eight-model line of midget thermocouple glands is available for pressure sealing two or four 20 to 24-



*Another new development using*

# B.F.Goodrich Chemical raw materials



New automatic letter sorter developed for U. S. Post Office by Burroughs Corporation, Detroit, puts 279 destination slots at disposal of each sorter, as compared to only 49 before. It ends much sorting and re-sorting by hand. The machine is sheathed in steel coated with Geon vinyl by U. S. Steel Corporation, Pittsburgh. B.F.Goodrich Chemical Company supplies the Geon vinyl.



## *U.S. Mail sorting goes automatic*

### **with new machine sheathed in steel coated with Geon vinyl**

This new automatic mail sorter converts the age-old "peek and poke" hand method of sorting letters by destination to a smooth, 43,000 letters-per-hour sorting by machine. 78 feet long and 10 feet high, the machine is sheathed with a versatile new combination—steel coated with Geon vinyl.

The Geon coating provides a soft, pleasant look and feel. It can be washed. It won't scuff or stain. The color is permanent and the coating protects the steel against both wear

and corrosion.

Geon-coated metals can be formed, bent, even projection-welded without damage to coatings. Products can be made to match the color combination or texture of almost any material.

Geon coatings also offer superior abrasion, electrical and chemical protection for the metal. It's another example of the way that versatile Geon is improving products and opening new markets. For more information, write Dept. GW-2.

B.F.Goodrich Chemical Company,  
3135 Euclid Avenue, Cleveland 15,  
Ohio. Cable address: Goodchemco.  
In Canada: Kitchener, Ontario.



**B.F.Goodrich Chemical Company**  
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**B.F.Goodrich**

GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

Standard  
Models in stock

## Just look at the SIZE of our latest Hoffman Electrical Enclosure!



MULTIDOOR  
NEMA 12 PANEL ENCLOSURE

These quantity-produced stock enclosures will save you engineering time and delivery time with assurance of superior quality.

They are manufactured to NEMA 12 and JIC standards and are completely oil-tight and dust-tight. Available in 3, 4 and 5 door models measuring 86" high, 15" deep and up to 15½" long. Made of 10 gauge steel with strong steel framework inside to provide rigid support. All seams welded, and there are no holes.

A mechanical door interlock is standard, and an electrical interlock is available. Doors have 3-point, roller latches for easy closing. Large interior panels are removable.

Stocked and sold by Electrical Distributors

### Do you have wire installation problems?

Would you like an easier way to install and modify wiring systems?

The Hoffman oil-tight LAY-IN Wireway is the newest and fastest way of installing wires with protection against oil, dust, dirt and water. You don't pull wires thru—you just lay them in along an entire wireway run.



USE THIS  
OIL-TIGHT  
TIME-SAVING  
**LAY-IN WIREWAY**  
(PATENT PENDING)

All covers including fittings are hinged to permit easy laying in of wires and subsequent modification. Covers are gasketed to seal out oil, dust and water. Four standard sizes: 2½" x 2½", 4" x 4", 6" x 6", and 12" x 6" in length up to 10' with Elbows, Crosses and other fittings. Made to JIC standards.



### Oil-tight Industrial Control Consoles

These handsome Hoffman units are immediately available from stock and save you design expense and delivery time. They are flexible in design with optional top section and optional writing desk. Rigid steel construction with welded seams. All panels removable and sealed against oil, dust and water.

**Hoffman ENGINEERING CORPORATION**  
Dept. MD-151, Anoka, Minnesota

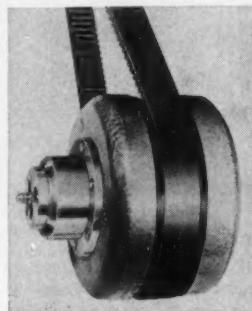
### NEW PARTS AND MATERIALS

gage bare-wire thermocouples. Stainless-steel glands are only 1¼ in. long x 9/16 in. hex, and provide a positive pressure seal for bare thermocouple wires, from 0.005 microns to 5000 psi. Low-mass, unshielded (bare wire) thermocouples produce maximum rate response with a time constant of less than 1 sec, insuring high temperature-sensing accuracy and control from -300 to +1850 F. Fittings can be furnished with or without thermocouple wires and can be used and reused by replacing ceramic insulators and sealant. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Circle 758 on Page 19

### Adjustable-Speed Pulleys

provide 3:1 ratios  
at 1 to 5 hp



Five adjustable-speed pulleys, including adjustable motor bases, V-belts, and V-belt sheaves, have been added to a line of cam-operated pulleys. Pulleys utilize narrow V-belts and provide speed ratios of 3:1. They are rated for 1, 1½, 2, 3, and 5-hp motors at 1750 rpm and for ¾ to 3¼ hp motors at 1150 rpm. Depending upon pulley model, standard bore sizes are 5/8, ¾, 7/8, 1, and 1 1/8 in. with bore lengths from 2½ to 3½ in. and motor travel for full speed range of 3 1/8 to 4 in. Lovejoy Flexible Coupling Co., 4932H W. Lake St., Chicago 44, Ill.

Circle 759 on Page 19

### Miniature Thermostat

is hermetically sealed,  
capsule type

Measuring only 1 3/16 in. over-all length and 1/4 in. diam, miniature Model 196A bimetallic thermostat

# SAVE 3 WAYS

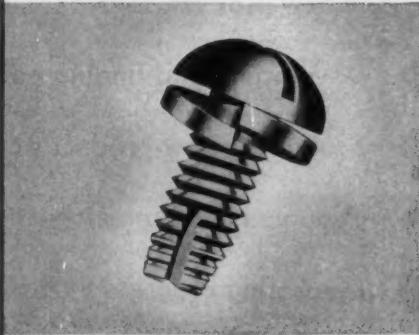
on production costs



EATON-RELIANCE  
SPRINGTITES®

1. Speed up assembly by reducing the number of motions on the production line with Eaton-Reliance Springties—which are bolts or screws preassembled with spring washers. Scientific light-line studies prove many motions are eliminated by using these fasteners.
2. Keep inventory balanced and make stock handling easier by always having the number of spring washers equal that of the screws or bolts. This also saves on paper work by reducing the number of stock requisitions and orders.
3. Minimize “sweep-out” waste by using one preassembled fastener instead of two fastener components. Being easier to pick up, Springties are less apt to be dropped, lost and wasted. In hopper-fed operations, preassembled fasteners are more efficiently and easily handled.

*Eaton-Reliance Springties are made from top quality steel, cold drawn to rigid specifications in the Reliance mill.*



*Write for  
our new 16 page  
full line catalog  
containing complete information.*



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GUIDE TO...**



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- Developing and finding new-product ideas
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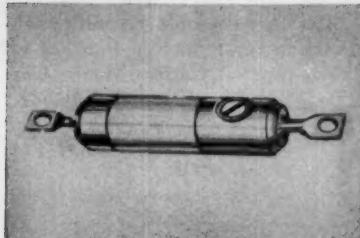
This collection of 17 helpful articles details the necessary steps to the development and engineering of new products. Written by Dr. Philip Marvin, well-known market consultant, this book is "required reading" for every engineer responsible for the development of new product ideas or the operation of a research program.

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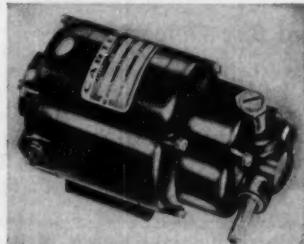
is rated at 1 amp at 28 v dc, or 1 amp at 115 v ac (noninductive load), and weighs only 0.083 oz. Hermetically sealed, capsule-type unit is for operation at temperatures from -100 to +300 F. Terminal supports of the two-element unit are solder-sealed to ends of high-strength, triple-coated, metallized ceramic tube. Thermostats have an inherently small temperature differential. They are available factory sealed and calibrated to within  $\pm 5$  deg of specifications. Defense Products Dept., George Ulanet Co., 413 Market St., Newark 5, N. J.

**Circle 760 on Page 19**

### Gear Motor

ten models have shaft outputs from 10 to 750 rpm

Classic gear motor provides suitable power for business machines, computers, medical equipment, electronic and geophysical equipment, movie cameras, teleprinters, scientific instruments, and duplicating machines. Ten standard single and double-worm-reduction models are available, with shaft outputs from 10 to 750 rpm. Gear train employs first worm cut directly on motor shaft for highest efficiency. Shaft position is changed easily to six 30-deg positions by means of six screws. Motor shaft runs on ball bearings, gear shafts on bronze sleeve bearings. All gears are lifetime-lubricated and sealed. Over-all size is 6 x 3-5/16 x 3-3/8 in. high and weight is approximately 5 lb.



## WHITNEY MSL\* CHAIN solves Another Drive Problem!...

on the **Ariens Imperial RIDING MOWER**



Thousands of owners know the quality engineering of the Imperial Riding Mower manufactured by the Ariens Co., Brillion, Wis., which is backed by over thirty years of engineering and manufacturing experience in rotary tillage equipment. When Ariens engineers originally developed the Imperial, they specified a drive chain that would stand up to abrasive dust and repeated shock loads. They selected Whitney MSL Chain . . . the lubricated-for-life chain that outlasts conventional chain as much as 3 to 1 . . . to assure customer satisfaction.

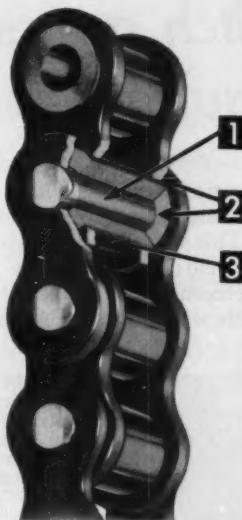
If you need the best chain drive, switching to MSL Chain is no problem, as all essential dimensions conform fully to ASA Standards, making Whitney MSL Chain completely interchangeable with any similar pitch chain.

By developing a chain that incorporates oil-impregnated, sintered steel bushings which give up oil under pressure and heat to lubricate every working part of the chain, Whitney has solved a basic problem: more damage is caused by faulty chain lubrication than by years of normal service.

In addition to providing built-in lubrication, inherent characteristics and configuration of Whitney Sintered Steel Bushings provide greater contact area between bushing and links, which permits high interference fit to pre-load links for maximum fatigue resistance.

Why not investigate the many advantages Whitney MSL Chain can bring to your chain drives? MSL Chain is carried in stock by Distributors in all parts of the country for prompt delivery. Write for MSL Chain Catalog.

\*Maximum Service Life



### WHERE AND HOW BUILT-IN LUBRICATION WORKS

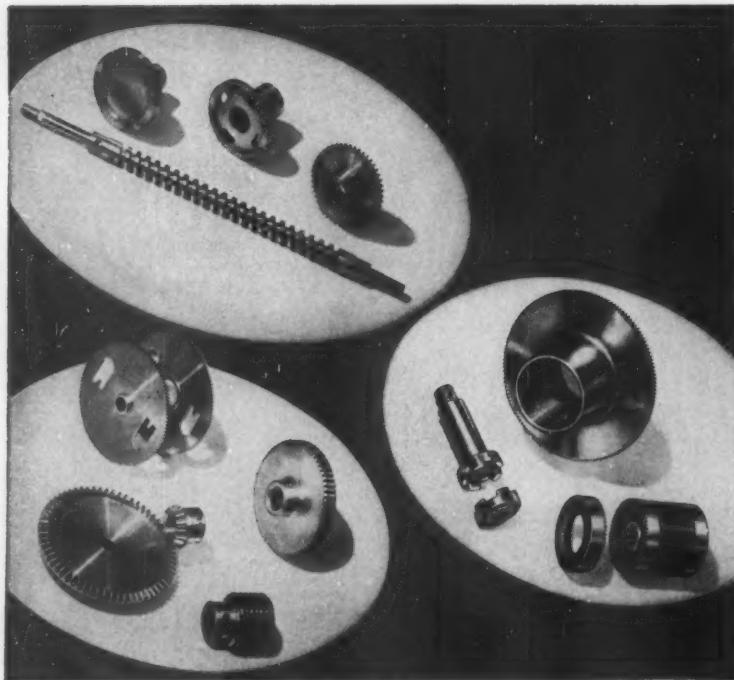
1. Protective oil film lubricates live bearing area between pin and bushing, minimizes wear by reducing metal-to-metal contact.
2. Oil impregnated bushings extend beyond surface of inside plates to act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by mis-alignment of sprockets.
3. Oil film on exterior surface of bushings provides constant lubrication between sprocket teeth and chain. No rollers are required, as the tough oil film on bushing surface provides smooth sprocket engagement, cushions impact, and reduces drive wear. When drive stops, bushings re-absorb oil, insuring a permanent oil supply for life of the chain.



**THE WHITNEY**  
a subsidiary of **FOOTE BROS.**  
**GEAR AND MACHINE CORPORATION**

**CHAIN COMPANY**  
4567 S. Western Blvd., Chicago 9, Illinois

**POWER TRANSMISSION DRIVES**



## small and fine pitch gears for precision equipment

No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.



**YOURS ON REQUEST**  
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. Write today.



**PERKINS**  
**MACHINE AND GEAR CO.**

Dept. 73 West Springfield, Mass.  
Telephone: REpublic 7-4751

### NEW PARTS AND MATERIALS

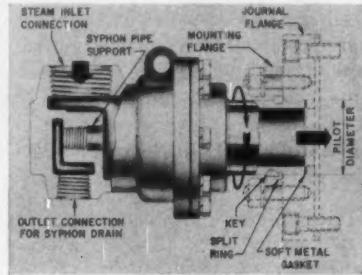
Units are available as universal, shunt, or series motors from 12 to 220-v input. Carter Motor Co., 2700 W. George St., Chicago 18, Ill.

Circle 761 on Page 19

### Rotary Joints

provide accurate control of concentricity

Improved convenience in installation and accurate control of concentricity are important features of Type CF rotary joints. Design eliminates need for threaded connection of rotary sleeve. Joint is



equipped with a machined straight rotating sleeve, in which outside pilot diameter is held to close tolerances. Attachment of joint to rotating drum, dryer, or roll is by means of a mounting flange keyed to rotating sleeve and drawn up against a spacing ring. Only an end wrench is required to draw up or loosen four nuts on mounting flange studs for installation or removal of joint. Sealing of joint against leakage at end of rotating sleeve is by use of a soft metal gasket. Joint is available in 2 1/2, and 3-in. sizes suitable for up to 200 psi saturated steam or 400 psi cold-working pressure. Also, hot oil under 100 psi can be handled up to 500 F. Barco Mfg. Co., Dept J 19, 500 Hough St., Barrington, Ill.

Circle 762 on Page 19

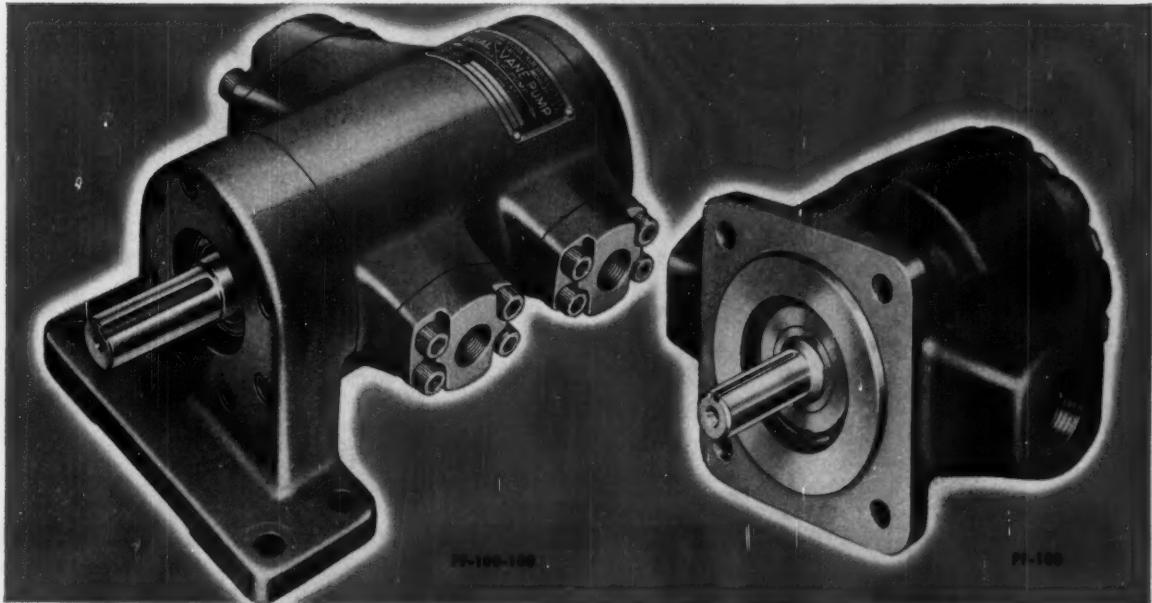
### Small Disc Clutches

have ball-bearing V-belt sheaves

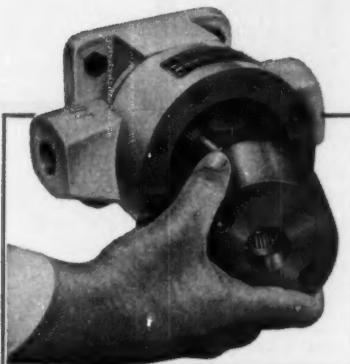
Types KB and KBB disc clutches feature integral single or double V-belt sheaves mounted on double-seal ball bearings. They are available in nominal OD sizes of 4 1/8,

# HYDRECO® PRESENTS—

## THE NEW SERIES PF-100 2000 PSI DUAL-VANE PUMPS



### NEW CAM DESIGN • IMPROVED CARTRIDGE DESIGN



#### DUAL-VANE CARTRIDGE CONSTRUCTION

A feature of Dual-Vane Pumps for many years . . .

HYDRECO Dual-Vane Pumps may be serviced in minutes because all pumping parts are contained in an easy-to-install cartridge. No special tools are required to replace a cartridge or change to one of a different capacity. Direction of Pump rotation is simply a matter of turning the cartridge end for end.

WRITE FOR  
ALL THE FACTS  
ON THE NEW  
PF-100 DUAL-  
VANE PUMPS

Significant superiority in performance, service life and quiet operation are the advantages now available to YOU in these advance design Dual-Vane Pumps. For builders of Machine Tools, Presses, Injection Molding Machines, etc. Series PF-100 Hydraulic Pumps answer your needs for continuous or intermittent Fluid Power applications at low initial cost. Single Pumps deliver 3 to 11 gpm at 1200 rpm, 2000 psi . . . Double Pumps to 22 gpm . . . foot and flange mounted models.

These new design advantages are also available in Dual-Vane Pumps of larger capacity — up to 140 gpm at 2000 psi.

**HYDRECO DIVISION**  
**THE NEW YORK AIR BRAKE COMPANY** 

9006-3 EAST MICHIGAN • KALAMAZOO • MICH.

Please send me full information on your NEW Series PF-100 Dual-Vane Pumps.

Name \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

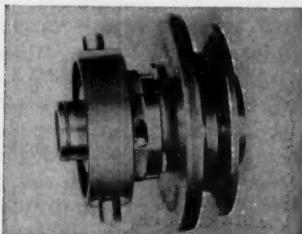
**FOR COOL  
HORSEPOWER  
IN ALL KINDS OF  
AIR MOVING  
REQUIREMENTS:**

TORRINGTON HAS  
ANALYZED THE INPUT  
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**THE TORRINGTON MANUFACTURING COMPANY**  
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$4\frac{3}{4}$ , and 5 in. for use with A and B belts having pitch diameters from 3.4 to 4.6 in. Clutches are for heavy-duty service on keyed stub or through shafts from  $\frac{5}{8}$  to  $1\frac{1}{4}$  in. in diam., at speeds to 4000 rpm. Clutch is engaged and disengaged with a manual shift lever. Cam action holds clutch in engaged position. Edgemont Machine Co., 2200 Home Ave., Dayton 17, Ohio.

Circle 763 on Page 19

### Slip-Ring Assemblies

with diameters from 1 to  $10\frac{1}{2}$  in.

Line of standard slip-ring assemblies now includes seven sizes with envelope diameters from 1 through  $10\frac{1}{2}$  in. Units are built from stock components and subassemblies to speed delivery time and reduce costs. Assemblies are of fabricated construction to provide maximum resistance to shock, vibration, and environmental conditions, and to permit the addition of rings when required. Rings are hard silver and brushes are silver graphite. Flat, stacked assembly with rings mounted above and below each barrier provides maximum number of rings in shortest axial length for rated capacities. Breeze Corporations Inc., 700 Liberty Ave., Union, N. J.

Circle 764 on Page 19

### Silicone Dielectric Greases

are chemically inert, soft, and workable

Two silicone dielectric greases for use in applications subjected to temperature extremes are soft, workable greases that are chemically inert and can be used over a broad pH range. Designated XS-4006 and SS-4005, greases maintain their consistency from  $-65$  to  $+400$  F. Both offer excellent dielectric properties as well as good water repellency and oxida-

### CLUTCHES FOR POWER CONTROL DESIGNS

## THE NEW HILLIARD-TWIFLEX Centrifugal Coupling

1

**AUTOMATIC**  
smooth starting  
with protection  
against overload  
shock.

2

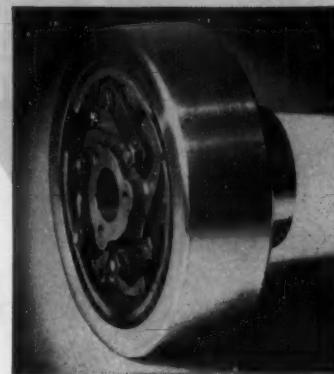
**FLEXIBLE**  
in all directions  
without any loose  
joints.

3

**ADJUSTABLE**  
to exactly suit the  
operating conditions.

4

**SIMPLE CONSTRUCTION**  
and easy assembly  
even in blind in-  
stallations.



**HILLIARD-TWIFLEX** Centrifugal Couplings provide automatic shockless power transmission and trouble-free operation even under relatively great misalignment without any lubrication whatsoever.

They are being used very successfully in the drive of compressors—agricultural sprayers—mixers—conveyors—generators—fans and blowers—pumps—hammer mills—crushers—winches and hoists—refrigeration equipment—textile machinery—and wherever smooth, efficient operation is needed.

Tests in a variety of installations for over five years prove the Twiflex is the practical solution to many drive problems.

WRITE TODAY FOR BULLETIN CE-3 WITH COMPLETE INFORMATION.

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**SINGLE REVOLUTION**  
CLUTCHES for automatic accurate control—electrical or mechanical—or intermittent motion, indexing, cycling and cut-off.  
Ask for Bulletin 239.

**OVER-RUNNING**  
CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action.  
Ask for Bulletin 231.

**SLIP CLUTCHES** for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands.  
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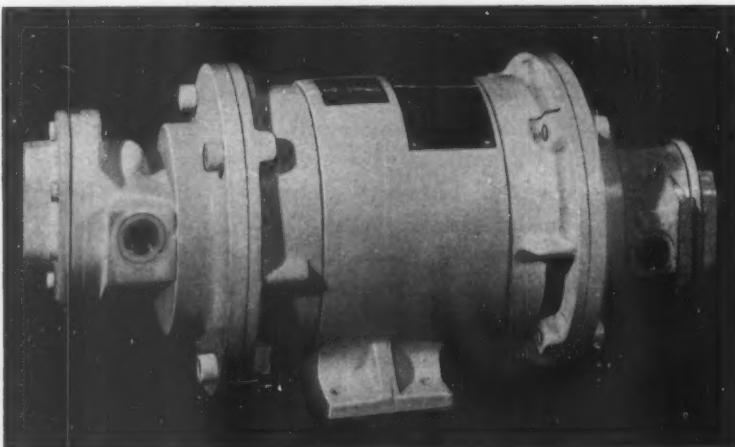
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

← Circle 551 on Page 19



This tracking antenna is an important part of the Air Force Ballistic Missile Early Warning System. Goodyear Aircraft Corp. developed it for R.C.A., prime contractor on the system.

## Why Goodyear Designers Choose Brown & Sharpe Pumps To Lubricate B.M.E.W.S. Antenna



One of four paired B&S pump units used in antenna.

**Problem:** Designers of this antenna needed 8 pumps, pre-mounted in pairs on opposite ends of 4 double-ended, "spec." motors. This would provide four compact units, to: (A) Replenish oil in the main drive system; control position of yoke on large, variable-displacement drive pump. (B) & (C) Supply lube oil for the whole antenna. (D) Lubricate a data gear box. The pumps must remain self-priming from minus 65°F to plus 160°F; must be rugged and long-wearing. (Antenna life requirement is 10 years.) Fast

delivery from a single manufacturer was preferred.

**Solution:** Brown & Sharpe pumps met all requirements. B&S high-pressure pumps (of a unique, long-wearing design) are used for (A), (B) and (C). B&S rotary geared units, available quickly, are used for application (D).

**Idea:** For the best solution to any pump problem — write Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, Rhode Island — or contact your nearest B&S engineer-representative.

**Brown & Sharpe**   
PRECISION CENTER

Circle 552 on Page 19

tion resistance. XS-4006 is an ideal insulating material for use around copper wire and splices. SS-4005 is designed for general-purpose electrical applications. Particularly suited for aircraft, automotive, and electronic applications, SS-4005 can be used as a corrosion inhibitor, water-repellent seal, insulator, lubricant, and damping and heat-transfer media. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Circle 765 on Page 19

## Wound-Rotor Motors

provide special starting characteristics



Wound-rotor Life-Line A induction motors are designed primarily for adjustable or constant-speed drives that require special starting characteristics. They are used wherever high starting torque with low starting current is required. Motors cover all standard ratings in frame sizes 254 through 326, which represents motors from 2 to 30 hp up to 1800 rpm. Class B insulation system offers excellent thermal stability, outstanding moisture resistance, and inertness to chemicals and dirt. Motors have permanently sealed and lubricated ball bearings. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 766 on Page 19

## Jumper Strips

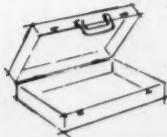
are single-piece units which speed wiring time

Ready-to-use jumper strips eliminate the need for series of jumpers between terminal stations on multiple adjacent station connections. Type RJ and RHS jumper strips are single-piece units made of brass, either nickel or cadmium plated. They are for use on standard Series 601 terminal boards or Navy Types



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## HURDLE THORNY APPLICATION PROBLEMS



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...a line of 800 to 1 hp favorites, built to make tough application problems seem easy

When it comes to building integral-motor-powered equipment, *make sure of your horsepower source!* Before you specify any motor brand, consult with your A. O. Smith Motor Man. He'll show you how the horses of A. O. Smith (single-phase integrals — 1-5 hp — polyphase — 1-800 hp) help users surmount application barriers.

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Milwaukee 1, Wisconsin, U. S. A.

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A complete line  
available from local  
stocks everywhere

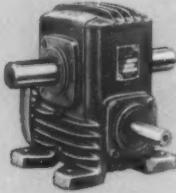
## NEW



U Series



P Series



S Series

These fin and fan cooled reducers give up to 80% more capacity in far less space. Over 100 models from 1/16 to 18 horsepower. Available with "C" flange motor mounts.

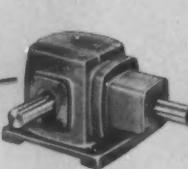
### Non-Ventilated Models



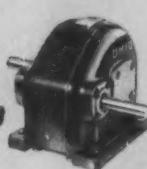
Single Worm



Double Worm



Bevel Gear



Helical Gear



Spur Gears



Worm Gearing



Miter Gears



Helical Gears



Fibre Gears



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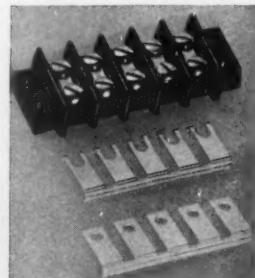


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#### NEW PARTS AND MATERIALS



6TB or 7TB. Type RJ jumper has closed-type connecting lugs with holes sized to accept No. 6-32 screws. Type RJS has spade-type connecting lugs requiring loosening of terminal screw to insert. Both are available with up to 23 connecting lugs. Channeled edge provides extra mechanical rigidity. Kulka Electric Corp., 633-643 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 767 on Page 19

#### Insulating Material

for precision electrical applications

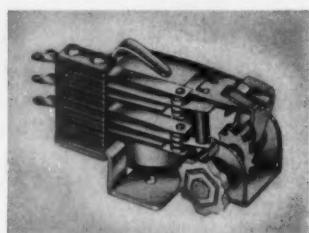
Spaulding 800 rod insulating material maintains high dimensional stability under conditions of high moisture. Available for precision electrical applications, it is available in bulk form of either linen or paper base, or can be custom fabricated. Excellent physical strength allows machining to close tolerances in a variety of fabricating techniques. Spaulding Fibre Co. Inc., 310 Wheeler St., Tonawanda, N. Y.

Circle 768 on Page 19

#### Impulse Relay

provides long, troublefree operation

Series 670 impulse relay insures long life and troublefree operation well in excess of 1 million steps. Each momentary impulse (up to 10 steps per sec) causes relay to reverse cam-





## Super quiet hydraulic components hush unique refuse loader

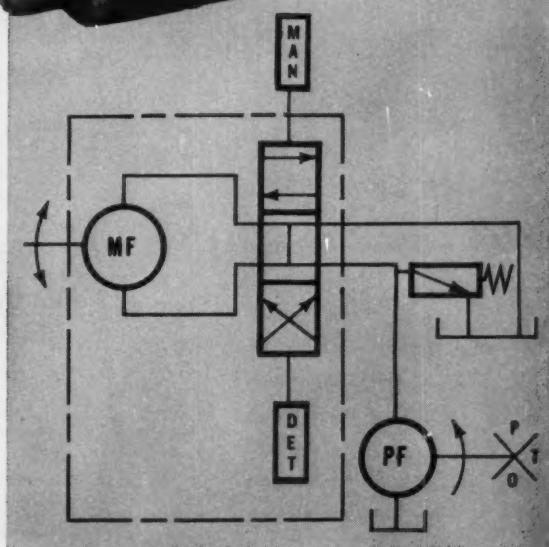
A Model H hydraulic pump generates the fluid power which energizes the motor and all the cylinders on this continuous loading and compacting refuse collector—the Roto-Pac produced by City Tank Corporation of Corona, New York.

### 80 decibels of sound

Municipal specifications demanded a quiet-running pump—maximum noise level 80 decibels when measured 34 inches from source. COMMERCIAL's Model H Pump meets this requirement handily and delivers constant volume at over 90% efficiency. The reason: precision-ground matched helical gears, oversize bearings, protected leak proof seals and patented thrust plates team up to maintain positive internal alignment—prevent seizing—dampen shock and reduce noise.



**ROTO-PAC'S** continuous loading and tighter compaction results in  $\frac{1}{3}$  more payload—cuts collection costs.



### 100% Hydraulic... 100% COMMERCIAL

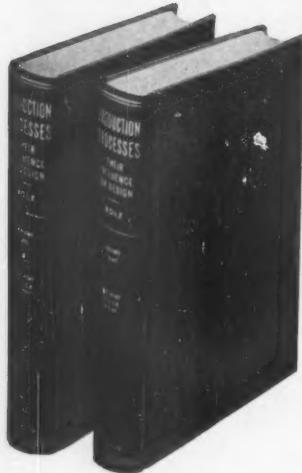
COMMERCIAL produces all of the fluid power components used to operate the Roto-Pac...the pump, valves, cylinders and motor. Drive for the escalator and rotary continuous-compaction plate is with the Model D hydraulic motor shown above with its corresponding J.I.C. symbolic circuit. Note how this motor and its control valve are built...two components combined into a single unit. Result: less mounting space required—less installation cost.

### Engineering experience available

Personal technical service and assistance on fluid power applications is yours for the asking. Send today for your copy of Bulletin 100-P4. Address inquiries to Commercial Shearing & Stamping Company, Dept. S-12, Youngstown 1, Ohio.

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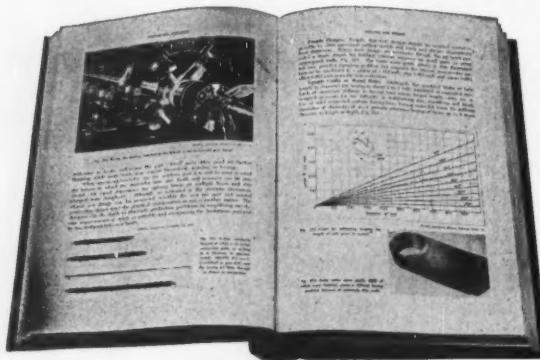
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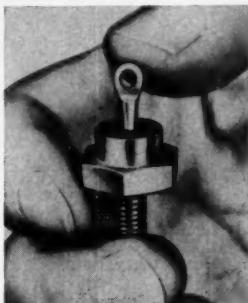
actuated contacts. Contact arrangements are up to DPDT, with ratings to 1500 w noninductive, or up to 20 amp locked motor current, motor load control on 115 v, 60 cycles. Coil voltages are to 230 v ac or 110 v dc. Applications include on/off control of lights, motors, appliances, and speakers. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill.

*Circle 769 on Page 19*

### Silicon Rectifier

has forward dynamic resistance of 0.009 ohms

Style 31 double diffused silicon rectifier is rated at 17 amp average at 25 C ambient temperature on a 5 x 5 x 1/16-in. copper heat sink. Peak inverse voltages range from 50 to 400 v in 50-v steps. Typical for-



ward dynamic resistance of 0.009 ohms is achieved by diffused junction techniques. **Syntron Co.**, 260 Lexington Ave., Homer City, Pa.

*Circle 770 on Page 19*

### Tantalum Foil Capacitors

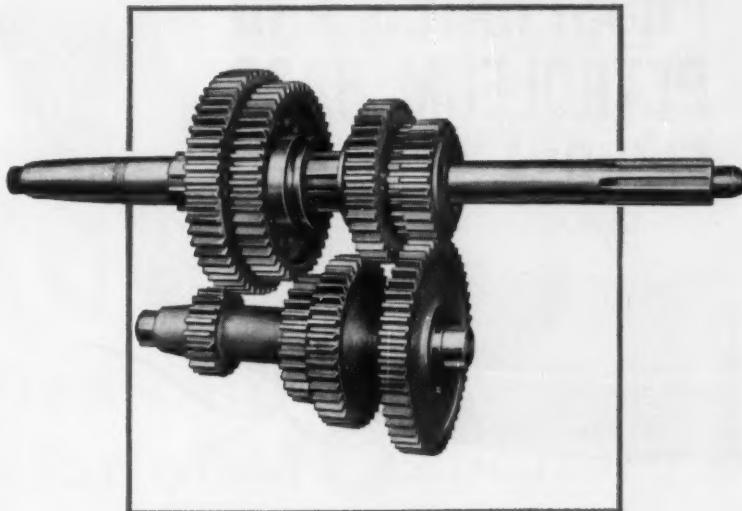
for applications where space is critical factor

TH-type miniaturized tantalum foil capacitors are designed for reliable operation over -55 to +125 C temperature range. They are produced in all capacity and voltage ratings of standard 125-C, TEH-type capacitors, but are shorter in length, and are suitable for use in applications where space is a critical factor. Capable of operation at 150 v or less, capacitors provide more capacitance in less space than standard high-temperature tantalum units. They are available with plain or etched foil for greater capacitance, polar or nonpolar con-

# BRAD FOOTE

# gears

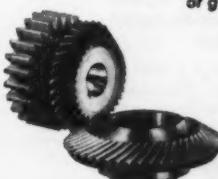
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## NEW PARTS AND MATERIALS

# USE IN BOTH PHOSPHATES AND PETROLEUM BASE FLUIDS!

### TECHNICAL MEMO ON LINEAR COMPOUNDS 8310-70 and 3283

- specially designed for O-Rings and V-Rings
- Versatile new elastomer material, homogeneous for O-rings... fabric reinforced for V-rings
- Highly resistant to a wide variety of fluids. Suitable for phosphate esters and petroleum base fluids, plus many other organic fluids
- Effective sealing in temperatures from -20° to +250°F.

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For detailed technical data—including a list of incompatible fluids—write today for Technical Bulletin 56702-1. Linear Inc., State Road and Levick St., Philadelphia 35, Pa.



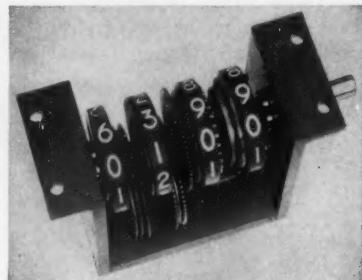
struction, contain a neutral electrolyte, and have long shelf and operating life over rated temperature range. Units are available for 10, 15, and 150-v operation with plain or etched foil in five case sizes from  $\frac{3}{4}$  to  $\frac{7}{8}$  in. lengths. Tansitor Electronics Inc., Bennington, Vt.

*Circle 771 on Page 19*

### Mil Counter

provides readings from 0000 to 6399 mils

Model 10519 mil counter has applications in radar indicators, computers, fire-control devices, and missile tracking devices. Counter provides continuous and consecutive readings in mils from 0000 to 6399



and return to 0000. Input shaft and units-counting drum are direct coupled, with one revolution providing 10 mils of indication. Unit combines light weight (6 oz), small size (2-23/32 in. long, not including shafts), and large characters (0.187 in. high) for fast, reliable reading. It is designed for continuous operation at 500 rpm and can be operated intermittently at 1280 rpm. Counter is reversible at any point in its cycle. It meets the requirements of MIL-E-5272A. Bowmar Instrument Corp., 8000 Bluffton Rd., Ft. Wayne, Ind.

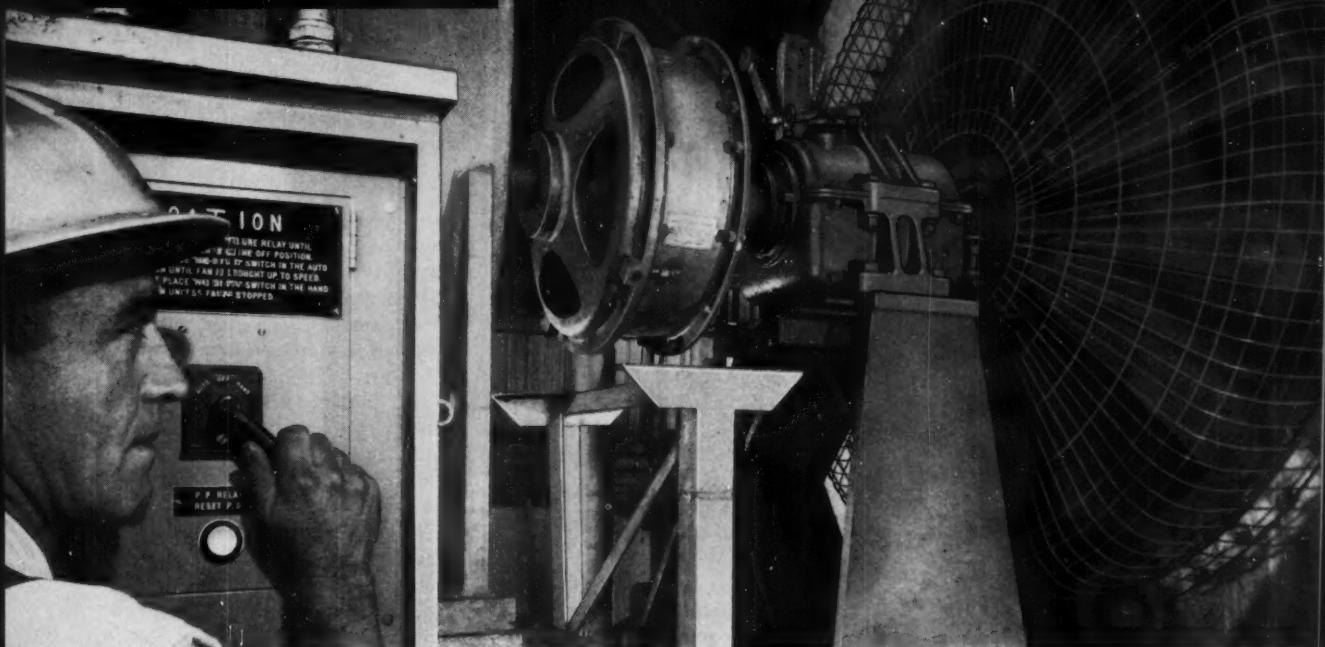
*Circle 772 on Page 19*

### Ball Valves

provide full flow  
and tight shut-off

McCannaseal and McCannaflow ball valves provide the full flow of a gate valve, tight shut-off of a globe or needle valve, and quick quarter turn of a plug valve. McCannaseal valve offers two-way flow, minimum pressure drop, self-adjusting seats, back-seated stem seals, top entry for

Modern power transmission with FAWICK Airflex Clutch. Clutch accommodates thermal expansion of shaft for 70" diameter fan, preventing damage to reduction gears and bearings at refinery steam plant.



## Fawick Airflex Clutches compensate for shaft expansion!

Ability to compensate for changing shaft dimensions is a performance bonus of FAWICK Airflex Clutches that can help you solve special power transmission problems.

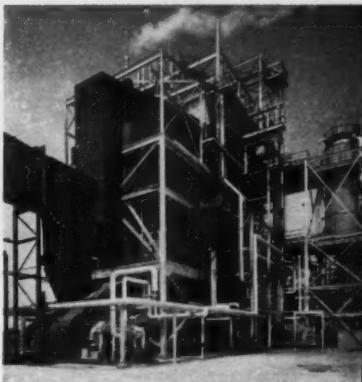
This has been proved in a steam plant application at Tidewater Oil Company's Avon (Calif.) Refinery. Here, forced and induced draft fans used in conjunction with the plant's furnace are driven through Airflex Clutches which provide an additional function of accommodating thermal expansion of the fan shafts.

Shaft elongation of  $\frac{3}{8}$ " to  $\frac{1}{2}$ " occurs after either fan has been started and the shaft comes up to normal operating temperature. All of this motion is absorbed within the FAWICK VC Ventorque Clutch which couples each shaft end to its power source. An automatic timing device momentarily disengages the clutch at regular intervals during shaft warmup, allowing the shaft-mounted drum to move further into the clutch element assembly. The friction shoes then regrip the drum in a new position. Fan speed and efficiency are not affected.

The FAWICK VC Ventorque Clutches are especially designed for the rugged duty encountered in this and other heavy equipment applications. They permit gradual fan start-up through slip-clutch action. Rapid heat dissipation through ventilated construction prevents loss of clutch efficiency. The clutches have required no maintenance since installation.

This is just one example of the many special ways in which FAWICK Airflex Clutches provide high-efficiency power transmission throughout industry. Call in your nearest FAWICK representative or contact the Home Office for expert consultation on your application.

Circle 559 on Page 19



Fans for Tidewater's boiler and stack system are dual driven, with main and auxiliary prime movers on opposite sides of each fan. Airflex Clutches on each fan shaft permit quick shifting from main to auxiliary drive without shutdown or time loss.

**FAWICK AIRFLEX DIVISION**  
**FAWICK CORPORATION**

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Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada



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Circle 560 on Page 19

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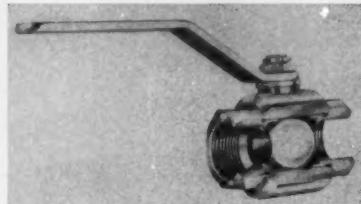
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## NEW PARTS AND MATERIALS



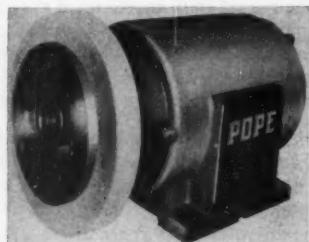
easy in-line maintenance, and permanent lubrication. McCannaflo ball valve (shown) incorporates compact design that features short end-to-end dimensions and low over-all height, positive indication of valve position, back-seating stem with double seals, interchangeable end pieces for universal assembly, and interchangeable seat design. Both valves withstand temperatures to 350 F. Maximum pressures are 700 psi for the McCannaseal and 1000 psi for the McCannaflo. They handle practically all fluids, semi-solids, compressed gases, and compressed air. Standard body metals include stainless steel, cast steel, ductile iron, cast iron, or bronze. Balls are chrome-plated carbon steel, bronze, or stainless steel. Valve sizes range from  $\frac{1}{4}$  to 6 in. in screwed or flanged end connections. Hills-McCanna Co., 4600 W. Touhy Ave., Chicago 46, Ill.

Circle 773 on Page 19

## Custom-Built Motors

in 1 to 20 hp with  
900 to 3600-rpm speeds

Precision, custom-built motors in NEMA frame sizes are for applications where a precision drive is a necessity. Motors are dynamically balanced to 25 millionths (0.000025) inch amplitude of vibration; maximum shaft runout is 50 millionths inch (0.00005 in.). Units are available in 1 to 20 hp with speeds from 900 to 3600 rpm, and with straight or tapered noses. Housing, extra-large shaft, and bearings provide



Circle 562 on Page 19→



**eye appeal that  
adds sales appeal**



**quickly applied...  
and removed**



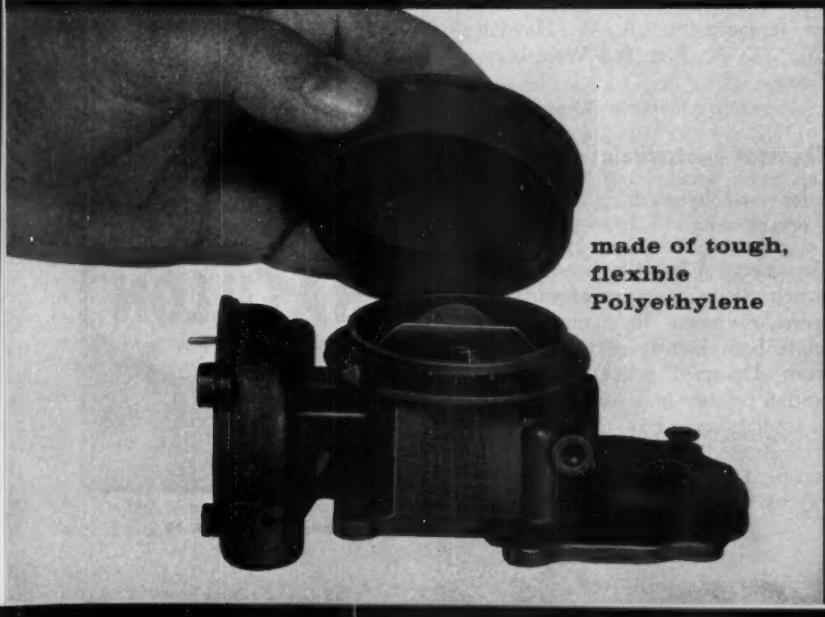
**product saving  
protection**



**won't chip,  
break, shred  
or collapse**

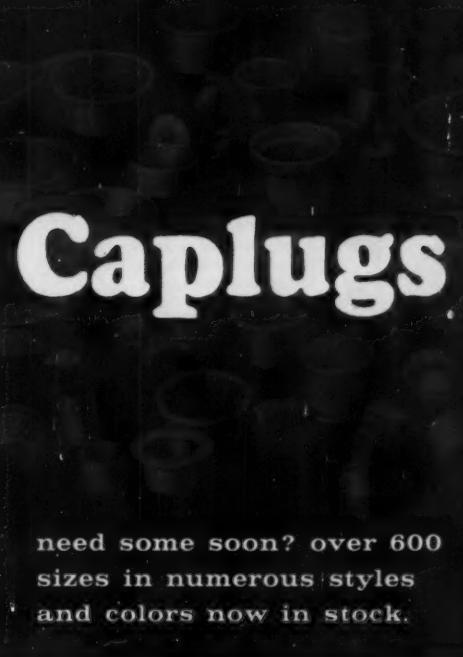


**save time,  
trouble and \$\$\$**



**made of tough,  
flexible  
Polyethylene**

# Capplugs



**need some soon? over 600  
sizes in numerous styles  
and colors now in stock.**

"kid glove" protection for tubing, threaded fittings and machined parts in process, storage and transit...get a kit full of samples in exchange for the coupon below.

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**CAPPLUGS DIVISION,  
PROTECTIVE CLOSURES CO., INC.  
2201 Elmwood Ave., Buffalo 23, N.Y.**

**MAIL a free assortment of Capplugs,  
literature and prices to us,  
without obligation.**

Name \_\_\_\_\_

Title \_\_\_\_\_

Firm \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

# now! get this NEW problem-solving money-saving Setko Catalog 23 **FREE**



- Includes new self-locking set screw selector chart.
- Latest styles of socket screws including: button heads, flat heads, shoulder screws, dowel pins.
- Complete information on cost-cutting Setko hopper feed method of inserting set screws.

Lists all standard set screw and socket screw products... plus many special types designed for unusual conditions of vibration; close precision setting; resistance to tampering, etc. Describes many specific ways in which Setko Set and Socket Screw products cut costs, improve product quality.

## "operation re-analyze for cost reduction"

A new Free Setko service designed to help you *cut costs—speed up production—increase quality*... Setko Engineers have helped many Companies save thousands of dollars through planned re-analysis of their socket, slotted and slotted set screws as well as socket cap screw needs. Write today for full information... Ask about "Operation Re-Analyze."

**send for FREE**

**Set  
Screw  
& Mfg. Co.**  
catalog 23  
today!

28 MAIN STREET  
BARTLETT,  
ILLINOIS

BUREAU OF  
CHICAGO



We specialize in solving puzzling set screw problems

Circle 563 on Page 19

## NEW PARTS AND MATERIALS

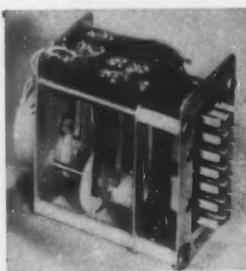
rigidity. Motor pictured shows a precision grinding application. Pope Machinery Corp., 261 River St., Haverhill, Mass.

Circle 774 on Page 19

## Repeat-Cycle Timers

feature long life,  
quiet operation

Low-cost, long-life repeat-cycle timers operate continuously for a minimum of one year. Long life and quiet operation are achieved by mounting special spring switches in molded contact blocks, while cams, cam followers, and gear assemblies



are molded nylon. Two printed-circuit cables are used to wire 12 output circuits. Parallel camshafts provide two cycling speeds. Timers measure approximately 4 x 3 x 2 in., including clear-plastic dust cover which permits visual inspection and reduces noise. Units are suitable for commercial or industrial application in appliances, vending machines, switchboard equipment, computers, and machine controls. Voltage, cycle time, and programming are adapted to application. Simple motor mountings, using only three screws, permit fast motor replacement. A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn.

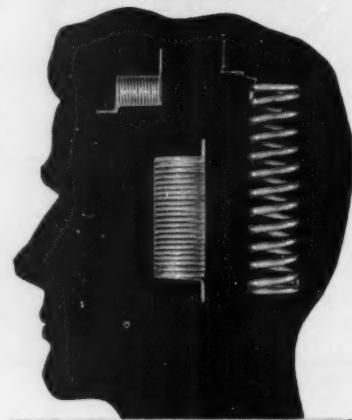
Circle 775 on Page 19

## Rheostat Footswitch

for variable-speed  
operations

Depression of No. 90 rheostat footswitch allows operators of variable-speed equipment to change speeds while both hands are left free for work. Designed primarily for operation by user in a seated position, footswitch stays cool under all operating conditions. Rugged variable resistor has maximum resistance of

# SPRINGS ON YOUR MIND?



• Your next thought should be of the Spring Engineers at John Chatillon & Sons. Send them your blueprints and specifications for study and recommendation.

• With more than 120 years of experience and knowledge at their command, they can provide you with the exact spring you require—on time, at competitive prices.

• Chatillon has the trust of the largest users of springs in the world because of the Chatillon reputation for filling orders that others would consider impossible.

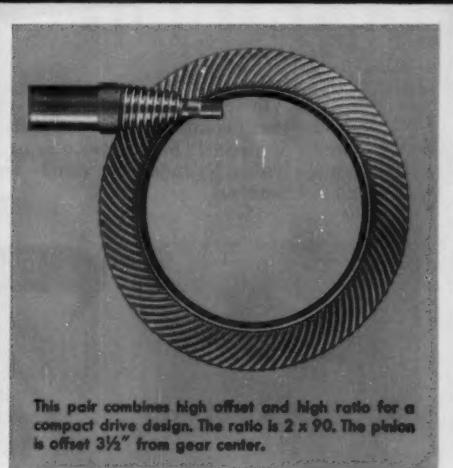
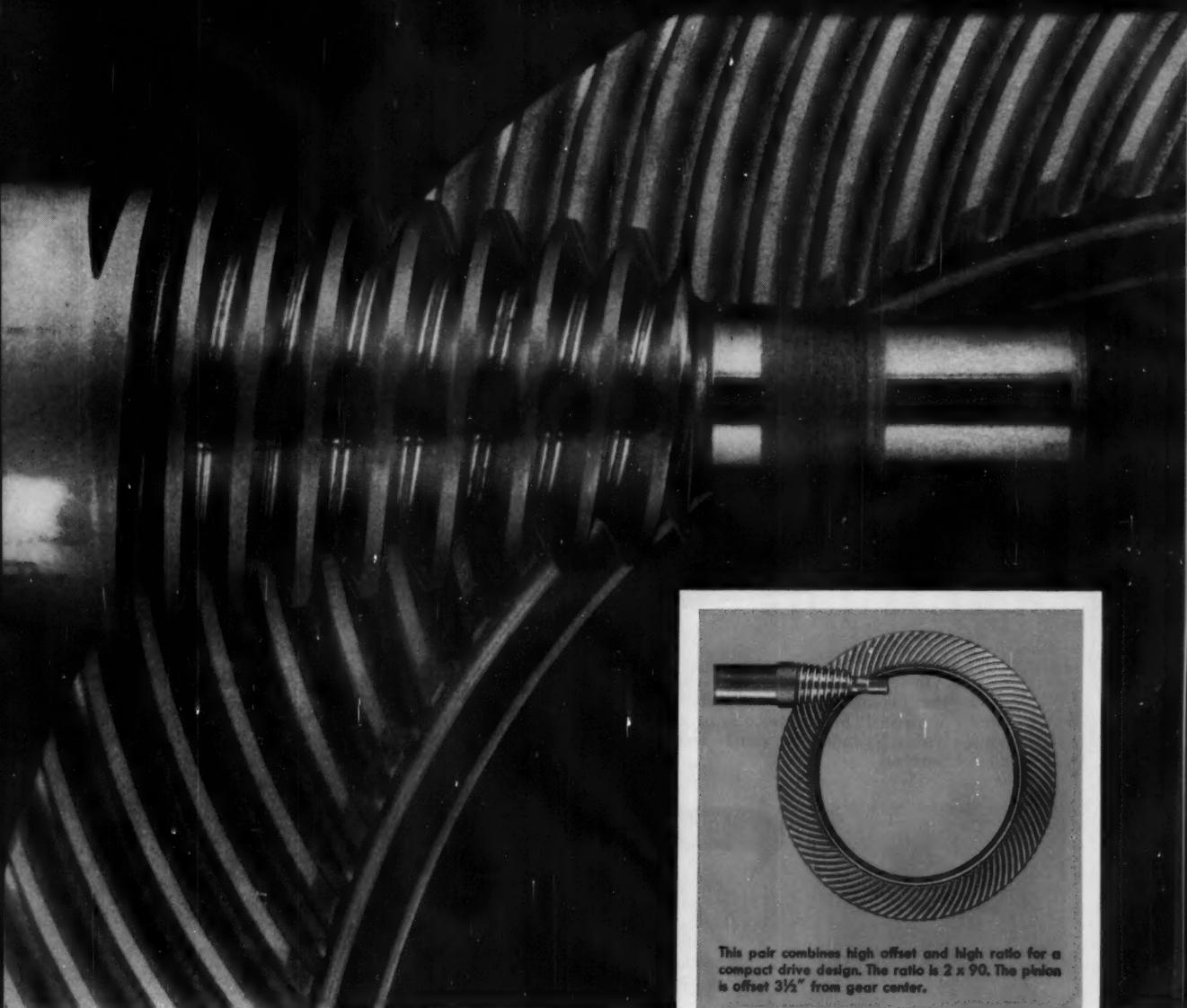
• Next time, benefit by the thorough knowledge of Chatillon Spring Engineers. They'll be glad to help you. Send your blueprints to: Department D-2.



85 CLIFF STREET, NEW YORK, N.Y.

Manufacturers of Precision Springs and Force Measuring Instruments Since 1835.

Circle 564 on Page 19



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

## See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid straddle* mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset or high-ratio pairs, the "wrap around" tooth

design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

**GLEASON WORKS**  
1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.  
Circle 565 on Page 19



## Pathon has Something for Everybody



Pathon Cylinders are designed to give you a highly practical cylinder that fits into almost every situation where a hydraulic cylinder is needed. Maintenance is at an absolute minimum because Pathon Cylinders are simple and easier to take apart and put together.

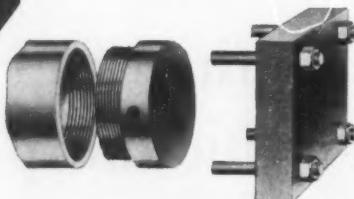


### For the Designer

Pathon's compact design saves valuable space, makes your designing job easier, and gives your equipment added dependability with a modern rugged appearance.

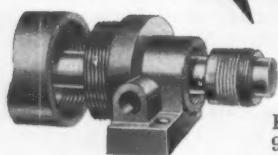
### For the User

Pathon's screw thread head design gives you up to 40% more strength than most tie-rod cylinders. This increased strength means less maintenance, longer life.



### For the Maintenance Man

Rod packing and bearing is externally replaceable and any part can be replaced without complete disassembly and the resulting "basket full of parts."



Pathon Hydraulic Cylinders are available in 9 mounting types, thirteen bore sizes— $1\frac{1}{8}$ ", etc., through 14", and three Series—for 1000 PSI, and 2000 PSI and 3000 PSI.

Write for Bulletin No. 22-A

**Pathon** MANUFACTURING COMPANY  
3823 PACIFIC AVE. • CINCINNATI 12, OHIO

FLUID OPERATED AND CONTROL EQUIPMENT



350 ohms, with unit rated at 0.8 amp at 125 v ac or dc. Phenolic housing assures long, troublefree service, and rubber feet on base give positive skid prevention. Linemaster Switch Corp., 432 Woodstock Terrace, Woodstock, Conn.

*Circle 776 on Page 19*

### Silicone Rubber

is low-viscosity RTV type for potting, impregnating

RTV-11 silicone rubber offers a lower viscosity than previously available in any silicone-rubber compound. It cures at room temperature to form a strong, resilient rubber, possessing excellent resistance to temperature extremes, ozone, weathering, and aging. Compound, which contains no solvent, has a typical viscosity of 120 poises. Material is easily pourable in and around irregularly shaped configurations, and is especially suited for potting, encapsulating, and impregnating of electrical and electronic components. Compound exhibits good electrical properties inherent with all silicone rubbers. Silicone Products Dept., General Electric Co., Waterford, N. Y.

*Circle 777 on Page 19*

### Adjustable-Speed Drives

provide dc voltages for driving dc shunt motors

Motor controllers for industrial power applications operate from 115-v, 60-cps, single-phase supply, and provide adjustable dc voltages





**MORE MUSCLE IN A SMALLER PACKAGE...THE NEW**

# **BLOOD BROTHERS "58WB"**

**UNIVERSAL JOINT**

To meet new drive line requirements on its 1960 model trucks, a major truck manufacturer needed a special, lightweight but strong universal joint—a unit that would provide greater torque capacity without increasing swing diameter. Rockwell-Standard engineers were consulted, and in a cooperative effort the new "58WB" was developed. It is now being used on several models in the manufacturer's 1960 line.

The design of the new "58WB" is applicable to medium-weight trucks, off-highway equipment, small crawlers and front-end loaders of approximately 1½ yards capacity. It can be made up as a complete drive line, furnished as a component part for a man-

ufacturer's own drive line, or utilized in close-coupled drives. The "58WB" offers these outstanding advantages:

★ **More capacity than any joint of comparable size.** The "58WB" provides 39,000 inch pounds torque capacity with a swing diameter of only six inches!

★ **Key-type yoke.** Requires only four bolts for installation on original equipment. Saves downtime for repairs.

For more details about the new "58WB" or for help in solving any problems involving universal joints or drive lines, write or call us today.

*Another Product of...*

**ROCKWELL-STANDARD**  
CORPORATION

Universal Joint Division, Allegan, Michigan



## NEW PARTS AND MATERIALS

# TRIPLE THREAT TO DRIVE COSTS

WHERE CORROSION IS A PROBLEM



ATLAS  
U.S.A.

## ATLAS *Electrolyzed* ROLLER CHAIN

### RESISTS CORROSION

Corrosion resistance compares favorably with any other corrosion resistant chain in most applications.

### LASTS LONGER

Actual wear-drive tests prove it lasts longer than alloy steel chain and much longer than stainless steel or other corrosive resistant chains. Has higher tensile strength . . . lower coefficient of friction.

### COSTS LESS

Atlas Electrolyzed Roller Chain is as much as 40% lower in price than any other corrosion resistant chain.

From the standpoint of cost, efficiency and longer wear Atlas Electrolyzed Roller Chain allows you to specify corrosion resistant chain on drives previously ruled out due to high cost and short chain life. Write for technical specification folder to . . .

ATLAS CHAIN & MANUFACTURING COMPANY

West Pittston, Pa.

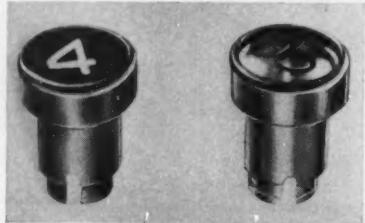


for driving dc shunt motors. Drives are available in three sizes: Junior for 1/100 to 1/8-hp motors, Size 1 for 1/4, 1/3, and 1/2-hp motors, and Size 2 for 3/4, 1, and 1 1/2-hp motors. Regulation is approximately  $\pm 4$  per cent of base speed, and speed range is to 50:1. Unit has instantaneous response, with vernier speed adjustment. Use of high-temperature silicon rectifiers provides high increase in surge safety factor. Magnetic Amplifiers Inc., 632 Tinton Ave., New York 55, N. Y.

Circle 778 on Page 19

### Pushbutton Caps

heavy-duty units  
are aluminum



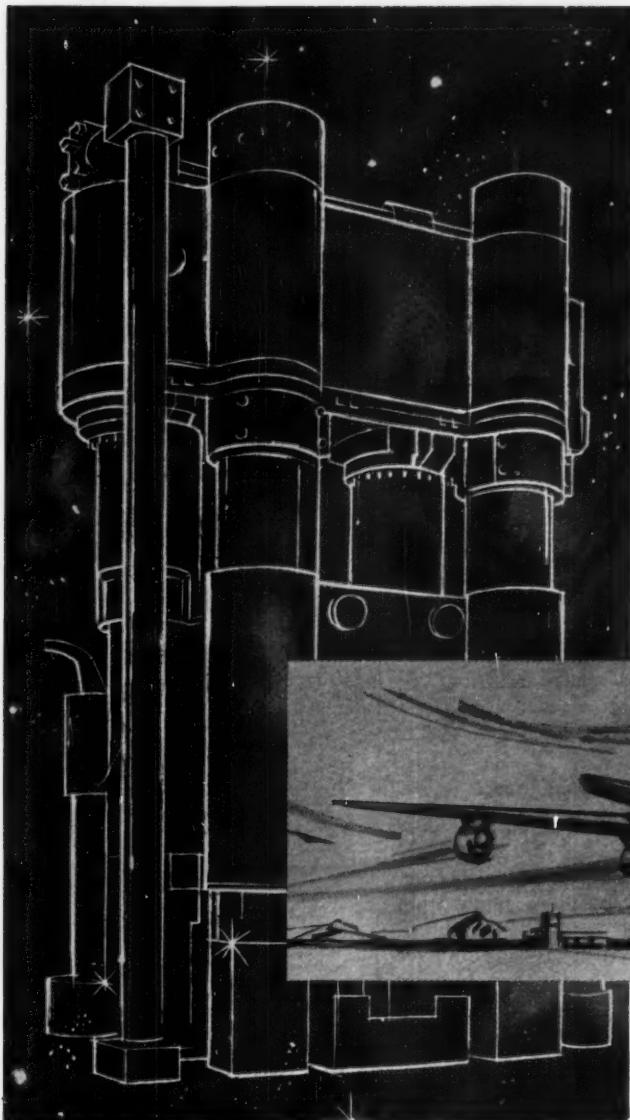
Aluminum caps for Micro Series 50PB and similar pushbutton switches are for any electrical installation requiring heavy-duty caps, where reliable switch control is important. One-piece aluminum body reduces breakage and excessive wear. Top of cap has 9/16-in. diam plastic insert for luminous indication of any circuit in use. Sel-Set Machinery Corp., Dept. PB, Box 1035, Salem, Oreg.

Circle 779 on Page 19

### Copper-Clad Laminate

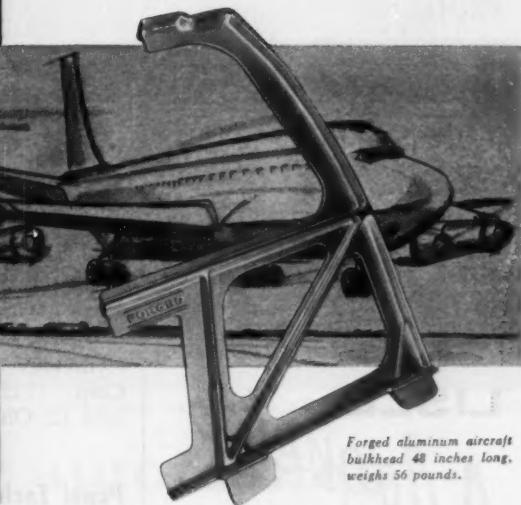
has high  
dimensional stability

Hot-punch copper-clad laminate, called Grade 320-R (with rolled copper foil) or 320-E (with electrolytically deposited copper foil), is made with a paper-base phenolic laminate which provides high insulation resistance and surface resistivity. Low dielectric loss, high dimensional stability, high mechanical strength, and resistance to fungus growth are additional characteristics. Both grades maintain electrical characteristics after prolonged exposure to high humidity. Base stock is translucent, and can



Modern hydraulic forging press exerts 35,000 tons pressure.

## HOW FORGED PARTS help airplanes haul bigger payloads



Forged aluminum aircraft bulkhead 48 inches long,  
weighs 56 pounds.

In an airliner, every pound of weight saved is worth hundreds of dollars . . . in revenue-making payload. And in military aircraft, pounds saved mean added miles-per-hour . . . or added load carried.

In commercial products . . . trucks, cars, materials-handling equipment . . . the pounds of dead weight you eliminate by using forgings make money year-after-year for the operator. The forging process lets you put the metal exactly where you need it to carry the load, withstand shock or vibration, endure torsion. And with not a surplus ounce of non-working weight going along just for the ride.

Forged parts are the designer's friend . . . strong where strength is needed, lowest in weight, twice-worked by original rolling of the best metals *plus* the hammer blows or high pressures of the forging process.

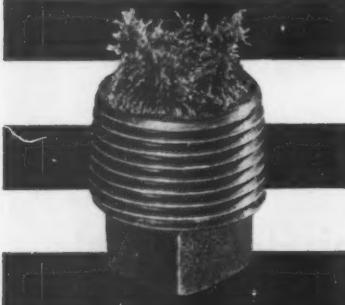
Write for literature to help you specify, design, and procure forged parts.

**When it's a vital part, design it to be **FORGED****

Drop Forging Association • Cleveland 13, Ohio

*Names of sponsoring companies on request to this magazine*

this much abrasive metal...



can destroy precision parts!

PROTECT

YOUR PRODUCTS

WITH LOW COST

## LISLE *Magnetic* PLUGS

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

**FREE** Samples for Testing in  
LISLE Your Product!

CORPORATION  
Clarinda, Iowa

Circle 570 on Page 19

262

## NEW PARTS AND MATERIALS

be cold-punched in thicknesses to 1/16 in. Material is offered in sheets of about 36 x 48-in. size. Thickness ranges from 0.02 to 0.25 in. Copper foil is available on one or both sides. Taylor Fibre Co., Norristown, Pa.

Circle 780 on Page 19

### Check Valves

for in-line mounting  
in hydraulic use

Two models have been added to line of hydraulic check valves for 3000 psi operating pressure. For in-line mounting, they have pipe thread connecting port in one end and Triple-lok machining on the



other end for JIC flared tube connection. Several sizes in each model have rated flow from 3 to 50 gpm. Tube OD connections range from  $\frac{3}{8}$  to  $1\frac{1}{4}$  in., and thread connections vary from  $\frac{1}{4}$  to  $1\frac{1}{4}$  in. Parker Hydraulics Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 781 on Page 19

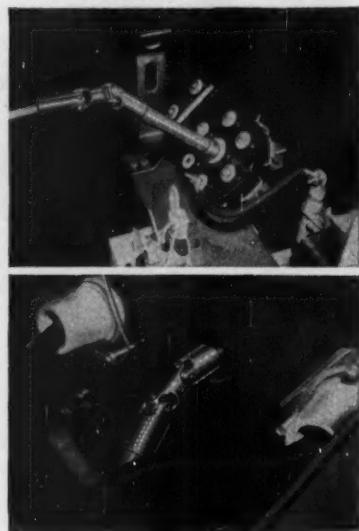
### Panel Enclosures

of sheet steel  
are watertight

NEMA Type 4 panel enclosures house electrical controls in areas which must be regularly hosed down or are otherwise very wet. Holes for watertight conduit connections are easily made anywhere on the cabinets. Cabinet doors have one-piece, solid neoprene gaskets and are sealed tightly by screw clamps on three sides. The fourth side of door has a continuous hinge. All cabinet seams are welded to prevent leakage. Each enclosure has a removable panel mounted on studs, and removable print pocket is located on the door. Exterior mounting feet are provided for wall mounting the unit. All door hardware is stainless steel. Standard



## CURTIS HELPS THIS SWITCH LIVE TO A RIPE OLD AGE



Pad-mounted transformers for underground power distribution systems are built to last a lifetime. They require a minimum of maintenance. Settings are changed infrequently. But when a change is required, this switch must operate smoothly and surely. To insure a long, dependable life, without freeze-ups or rust-outs, the manufacturer equipped it with a Curtis C-646 1" O.D. Stainless Steel double universal joint.

This kind of dependability is the stock-in-trade of Curtis joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, continuous testing, inspection and quality control at every stage of manufacture — these are some of the things that make Curtis joints your most dependable buy.

**14 SIZES ALWAYS IN STOCK**  
 **$\frac{3}{8}$ " to 4"**

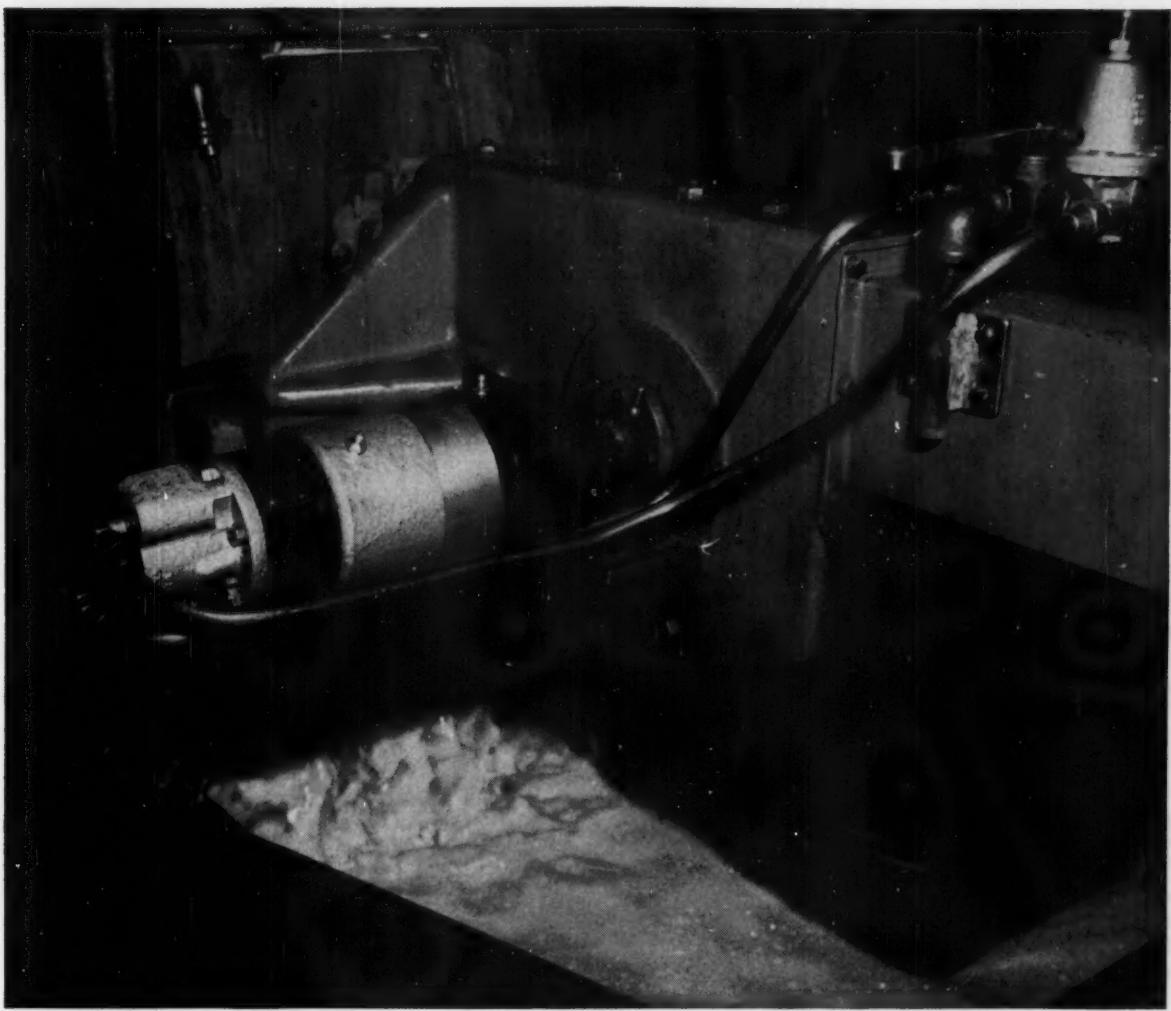
Not sold through distributors. Write or phone Republic 7-0281 for latest catalog, free engineering data and price list.

**CURTIS**  
UNIVERSAL JOINT CO., INC.

53 Birnie Ave., Springfield 7, Mass.

As near to you as your telephone. Exclusively a manufacturer of universal joints since 1919

Circle 571 on Page 19



Note simplified mounting and easily installed control of this Gardner-Denver air motor.

## Idea-power for automation



AT HOME EVERYWHERE

Gardner-Denver parts and service facilities in our offices throughout the world help keep quality Gardner-Denver products on the go wherever they go.

Looking for a motor that will work hard in continuous or intermittent service? Need motive power in corrosive, acid or dusty atmosphere? Gardner-Denver air motors may solve your problem. You'll find these advantages hard to top:

- High starting torque • Compact design • Variable speed
- Remote control • Consistent torque output • Reversibility without power loss • Instantaneous response • Won't spark
- Can't burn out.

Gardner-Denver 5-cylinder radial air motors, 1½ to 16 hp; axial-piston air motors, 0.6 to 2.7 hp; rotary vane air motors to 1.5 hp, straight and offset spindles. Write for information.



EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

# GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario



sizes for single-door, wall-mounted models range from 16 x 12 x 6 in. to 60 x 36 x 10 in. **Hoffman Engineering Corp.**, Anoka, Minn.

*Circle 782 on Page 19*

### Medium-Soft Grease

has excellent  
antiweld properties

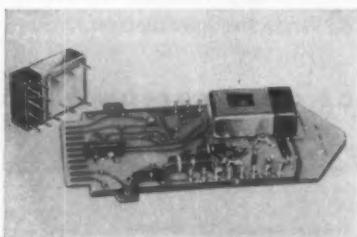
Synthetic antiseize compound for high-temperature applications, called Anderol L-751, is a mixture of a thermally stable silicone oil with a solid-type lubricant, blended to the consistency of a medium-soft grease. Excellent thermal stability and antiweld properties meet requirements for high-temperature ranges of 400 to 600 F. Compound is available in 1 and 5-lb cans, 14-oz cartridges, and 35, 100, and 400-lb drums. **Industrial Lubricants Div., Lehigh Chemical Co.**, Chestertown, Md.

*Circle 783 on Page 19*

### Electronic Components

are subminiature  
module types

Subminiature, environmentally tested electronic components are designed for printed-circuit cards. Modular ceramic capacitors and side-mounted relays meet requirements of 0.100-in. gridding used on standard printed circuits, and will not project further than 0.400 in. limit required for plug-in card components. Capacitors range from 47 to 56,000 mmf. Available in parallel lead, axial, or feed-through config-

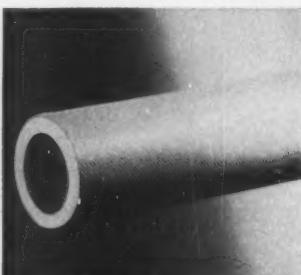


urations, they are stable over a full range of operating temperatures from -55 to +150 C, with capacity variations limited to  $\pm 10$  per cent of room temperature capacitance. Side-mounted relays mount to the circuit board with over-all height not exceeding 0.400 in. They have a broad operating temperature range from -65 to +125 C, ambient. With epoxy-potted connectors, hermetically sealed relays withstand acceleration forces to 100 g, vibration forces to 25 g, and mechanical shock to 125 g along all three major axes. **Electronic Components Div., Telecomputing Corp.**, 12838 Saticoy St., North Hollywood, Calif.

*Circle 784 on Page 19*

### Insulation Envelope

covers wires, cables, pipes  
subjected to heat



Insulation envelope of coated Dacron is for use on wires, cables, or pipes subjected to extreme hot spots. Envelope zips on in seconds. It withstands temperatures to 300 F for a period of 100 hr or more, and 400 to 450 F for 10 min. All sizes and thicknesses are available. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles, Calif.

*Circle 785 on Page 19*

### Nickel-Chromium Alloy

for fine-drawn resistor  
and potentiometer wire

Modified 80-20 nickel-chromium alloy possesses uniformity of electrical, physical, and mechanical properties required in the manufacture and application of precision wire-wound resistors and potentiometers. Chromel-R consists of 74 per cent nickel and 20 per cent chromium plus small percentages of other alloying elements which produce metallurgical changes during processing which greatly improve electrical

**THE**

"V" PACKINGS

**H**

"O" RINGS

**CUP PACKINGS**

**U**

ROD & SHEET PACKINGS

**G**

PRECISION MOULDED RUBBER PARTS

**T**

FIRE-RESISTANT HYDRAULIC FLUID

**HYDRAULIC FLUIDS**

**N**

ON-THE-JOB SERVICE

**LINE**

# How to select COMPATIBLE Packings for fire-resistant hydraulic fluids!

Use this handy guide for your protection in selecting packings for fire-resistant hydraulic fluids. It's your guarantee of a completely unbiased recommendation . . . for it comes to you from the only manufacturer who makes both packings and fluids for any industrial hydraulic system. For details or help on any hydraulic packing problem, call your Houghton Man, or write: E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

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THE ONLY  
COMPLETE LINE OF  
**PACKINGS & FLUIDS**  
FOR ANY  
INDUSTRIAL HYDRAULIC  
SYSTEM

TYPE OF FIRE-RESISTANT HYDRAULIC FLUID	COMPATIBLE PACKING COMPOUNDS*	HOUGHTON PACKING BRANDS
Water-Glycol	Homogeneous Buna N	Vix-Syn 10V70—O-Rings and U-Cups; Vix-Syn 10V90 "V's"
HOUGHTO-SAFE 600 Series	Fabricated Neoprene	Vix-Syn 3081 Cups and 1081 "V's"
Phosphate-Ester	Homogeneous Butyl	Vix-Syn 10V70-132 O-Rings and U-Cups; 10V85-94 "V's"
	Fabricated Butyl	Vix-Syn 3067 Cups and 1067 "V's"
HOUGHTO-SAFE 1000 Series	Leather-Impregnated with Polysulfide	Vim Leather No. 1243 Cups, "U's", "V's" and Flanges
	Leather-Impregnated with Wax	Vim Leather No. 1231 Cups, "U's", "V's" and Flanges
Water-Oil Emulsion	Homogeneous Buna N	Vix-Syn 10V70 O-Rings and U-Cups; 10V90 "U's"
	Fabricated Neoprene	Vix-Syn 3081 Cups and 1081 "V's"
HOUGHTO-SAFE 5040 Series	Leather-Impregnated with Polysulfide	Vim Leather No. 1243 Cups, "U's", "V's" and Flanges
	Leather-Impregnated with Wax	Vim Leather No. 1231 Cups, "U's", "V's" and Flanges

\*Under certain conditions of temperature, pressure or chemical composition, special packing materials may be necessary. When in doubt, consult your Houghton Man first.



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# Wanted: Engineers

*with an interest in writing*

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on **MACHINE DESIGN**, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, **MACHINE DESIGN**, Penton Bldg., Cleveland 13, Ohio.

**MACHINE DESIGN**

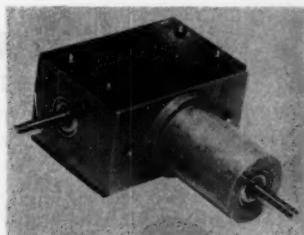
characteristics of finished fine-drawn wire. Specific properties include electrical resistivity of 800 ohms per circular mil foot at 20°C, and low controlled temperature coefficient of resistance within  $\pm 0.00001$  ohm/ohm/deg C over operating temperature range of -65 to +150°C. Wire is suitable for use on a wide range of close-tolerance electronic control applications. Wire sizes range from 0.0031 down to 0.0004 in. diam, available bare or insulated with various types of enamel coatings to meet specific application requirements. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

**Circle 786 on Page 19**

### Gearboxes

are miniature right-angle types

Type BA miniature right-angle miter gearboxes are assembled with precision ball bearings. Approximate over-all size is  $\frac{7}{8} \times \frac{1}{2} \times 2$  in. Units are stainless-steel clear passi-



vated, and frame is aluminum anodized. They are suitable for getting drives around corners. Precision 2 miter gears provide minimum backlash to better than 10 min, with variable mounting combinations. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

**Circle 787 on Page 19**

### Transparent PVC Hose

is nylon reinforced for high-pressure use

Transparent PVC hose reinforced with open-mesh nylon withstands pressures to 1500 psi, yet retains qualities of standard plastic hose. It is recommended for factory air lines, pneumatic equipment, fuel pressure lines, oil lines, and high-pressure machinery. An opaque grade is available for aircraft fuel lines and similar applications. Ny-



SS-5  
DP-DT spring return  
0.5-amp. @ 125v ac-dc  
U.L. Inspected.

SS-15  
SP-DT pushbutton, momentary contact, 1-amp. @ 125v ac  
U.L. Inspected.

SS-16  
3-position special  
3-amps. @ 125v ac  
U.L. Inspected.

## THINK HOW YOU CAN



SS-31  
3-position, 3-amps  
@ 125v ac  
U.L. Inspected.

SS-32  
SP-DT, 1-amp.  
@ 125v ac-dc  
U.L. Inspected.

SS-33  
DP-DT, 3-amps  
@ 125v ac  
U.L. Inspected.

## IMPROVE YOUR PRODUCT



SS-50  
DP-DT miniature,  
0.5-amp. @ 125v ac-dc  
U.L. Inspected.

SS-34  
SP-DT, 3-amps.  
@ 125v ac  
U.L. Inspected.

SS-36.1  
SP-DT, 6 amps.  
@ 125v ac  
U.L. Inspected.

New! HEAVY DUTY TYPE

## WITH THESE LOW COST



SS-26.1  
SP-DT, 3-amps  
@ 125v ac  
U.L. Inspected.

SS-9  
SP-DT spring return,  
3-amps @ 125v ac  
U.L. Inspected.

SS-18  
4-position special,  
3-amps. @ 125v ac  
U.L. Inspected.

## STACKPOLE SWITCHES!

### Get This GUIDE TO MODERN SWITCHING ▶

Ask for 8-page Switch Bulletin RC-11D

World's largest slide switch line—over 12 low cost standard types—dozens of economical adaptations. NEW colored knobs. Special conventional and miniaturized switches designed and produced for large quantity users. Electronic Components Division, STACKPOLE CARBON COMPANY, St. Marys, Pa.

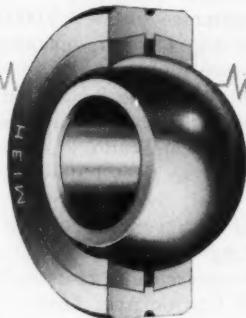


# To Eliminate Vibration

in Missile Trays Stored in  
Naval Vessel Missile Magazines.



Hydraulic damping devices are necessary to dampen vibration experienced in shipboard stowage of the TALOS missile trays. The Buffalo Hydraulics Division of Houdeille Industries, Inc. designed and built this Missile Tray Damper to physically isolate the missile itself from the vibrations that could be experienced during stowage.



With the misalignment which can be expected of equipment used on shipboard it was necessary to use a reliable, inexpensive self-aligning rod end such as

## HEIM *Unibal*® SPHERICAL BEARING

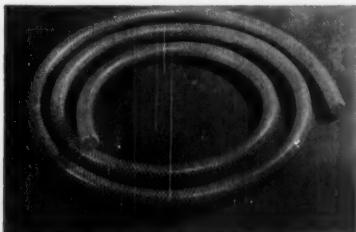
At one end of the damper is a male threaded HMX-6FG Heim rod end with a flush-type lubricating fitting; and opposing this, a Heim LS-6 Unibal spherical bearing is locked into the damper housing.

The unit which uses MIL-F-17111 Fluid has an adjustable damping range from 30 to 600 lb/in/sec, and is designed for continuous operation at  $\pm .1$  inch at 7 cps or normal operation of  $\pm .031$  inches at 5-15 cps and  $\pm .015$  inches up to 25 cps. The design life is 50,000 hours.



Please write direct for complete catalog or engineering aid.

**THE HEIM COMPANY**  
FAIRFIELD, CONNECTICUT



lon braiding enclosed within wall is protected from abrasion and penetration of oil or dirt. Hose resists gasoline, sea water, oils, high-octane fuels, coal and butane gases, and most chemical solutions. Working temperature ranges from -5 to +170 F. Bursting pressure of  $\frac{1}{8}$  in. ID hose is 1500 lb psi, of  $\frac{1}{4}$  in. is 1200 lb psi, and of  $\frac{1}{2}$  in., 800 lb psi. Standard sizes range from  $\frac{1}{8}$  to  $1\frac{1}{4}$  in. ID. Any conventional fittings can be used. Newage Industries, 222 York Rd., Jenkintown, Pa.

**Circle 788 on Page 19**

### Electric Vibrator

moves materials through bins, chutes, hoppers

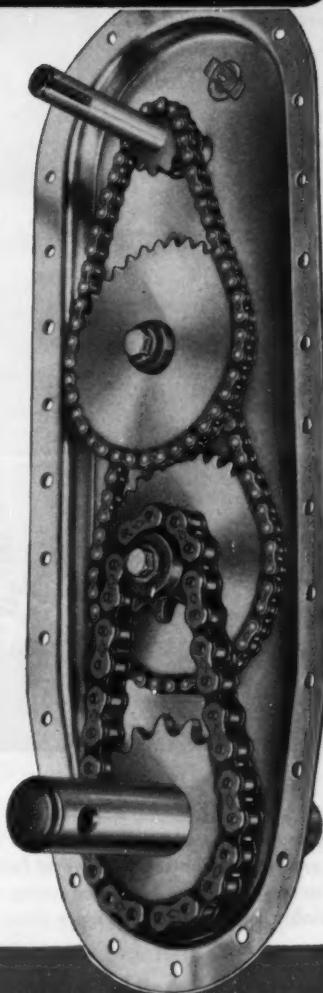
Explosionproof electric vibrator called RC-32 is a totally enclosed unit which moves stubborn materials through bins, chutes, and hoppers. It is UL approved for use in Class I, Group D conditions which include atmospheres containing natural gas, gasoline, naphtha, and similar vapors. Operation is practically noiseless and maintenance requirements are minimal since unit uses no pulleys, belts, or springs. Vibrator delivers 3600 vibrations per minute with 60-cycle current. Vibration force is produced by eccentric weights which are fastened on each end of rotating motor shaft. Seven separate settings permit adjustment of vibration impact from 385 to 1100 lb. Vibrator is available in three phase, either 220 or 440 v ac, with an input of 500



You can solve many problems better and at lower cost with **DIAMOND** Roller Chain



Farm and Garden Implements are  
**DIAMOND**  
**EQUIPPED** for  
STAMINA, POWER, ECONOMY



● Specially designed transmissions, such as the one shown above for the Merry Mover, are equipped with **DIAMOND** Roller Chain for full-torque power transmission, rugged durability . . . operating economy.

From self-propelled garden implements to heavy farm machinery, leading agricultural equipment builders specify **DIAMOND** Roller Chain. When you need chain, specify **DIAMOND**. Traditional high quality assures long, trouble-free life.

● Write for catalog containing complete information on **DIAMOND** Roller Chains and Sprockets. Engineering assistance is available.

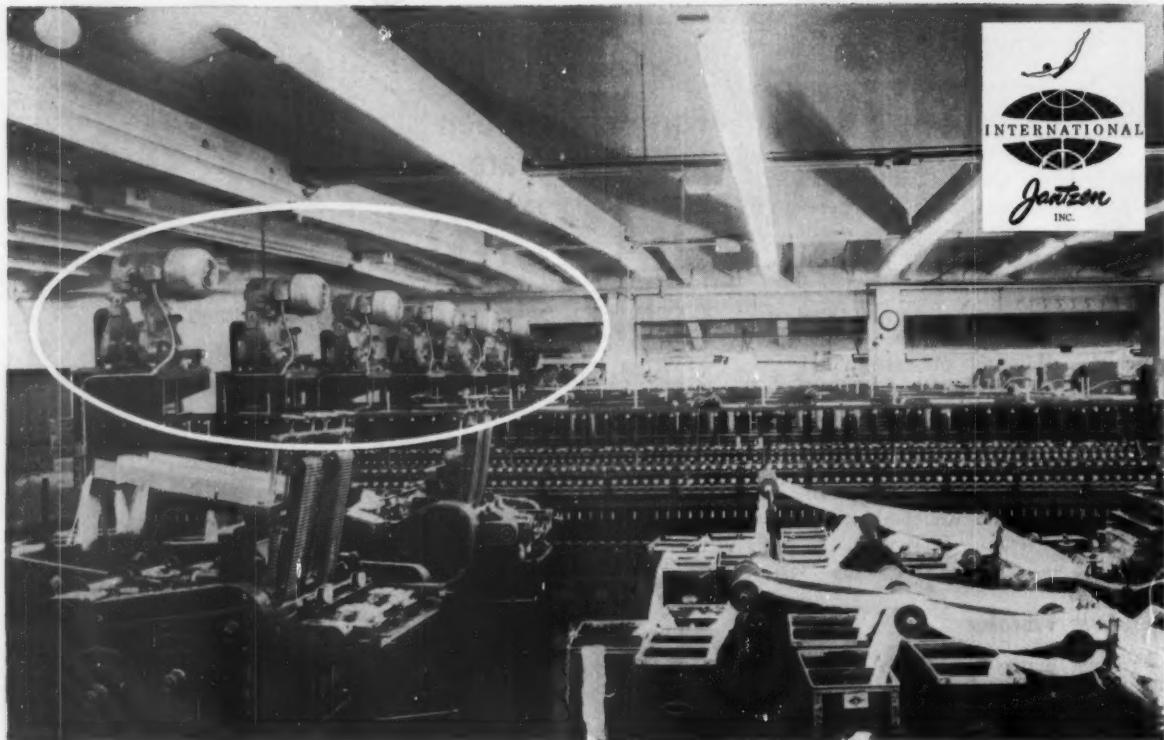
**DIAMOND CHAIN COMPANY, INC.**

A Subsidiary of American Steel Foundries  
Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana  
Offices and Distributors in All Principal Cities

**DIAMOND** ROLLER CHAINS

# FOR INCREASED PRODUCTION AND FLEXIBILITY...

## JANTZEN USES STERLING SPEED-TROL VARIABLE SPEED DRIVES



Because quality of product depends so much on quality of production, Jantzen, Inc. world-famous for fine sportswear and textiles, has been using Sterling Speed-Trol variable speed drives for more than 15 years.

Jantzen has described its experience with Sterling Speed-Trols as follows:

"The Speed-Trol allows us to start the machine at low speed. The use of the Sterling Speed-Trol also means that a wider variety of spinning can be accomplished— infinite speed variation is always available. The speed of the drives can be changed while running, to facilitate operation at the most efficient speed as determined by atmospheric conditions, static electricity build-up and varying types of materials.

"25 to 30% increased production, low maintenance costs, and uninterrupted operation result from the use of Sterling Speed-Trol Variable Speed Drives."



Only STERLING SPEED-TROL provides these features for reliable speed control:

- Positive coordinated control of both pulleys—"no springs"
- Maximum pulley life because:
  - (1) variable pulleys ride on hardened, chrome-plated, precision-ground, keyed shafts;
  - (2) large grease reservoirs provide a film of protecting lubricant.
- Longer belt life...no additional load from spring.
- Greater safety...No injuries from spring flying loose during maintenance.

For additional information about the unique advantages of Sterling Speed-Trols, ask for your free copy of Bulletin No. 195A. Write to:



# STERLING

ELECTRIC MOTORS, Inc.

5401 TELEGRAPH ROAD • LOS ANGELES 22, CALIFORNIA

Offices and stocks in all principal cities. Over 400 distributors throughout the country to serve you.

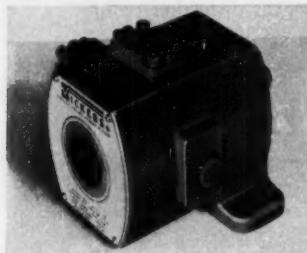
w. Weighing 51 lb, unit is 9 in. long, 8½ in. wide, and 6 in. high. **Cleveland Vibrator Co.**, 2828 Clinton Ave., Cleveland 13, Ohio.

**Circle 789 on Page 19**

### Variable Vane Pump

is available in 6-gpm size

New 6-gpm delivery unit has been added to a line of vane-type variable-volume hydraulic pumps. Designed for low cost machine tool drill feed and automation applications, unit will find wide use in circuits that require pump delivery to vary according to system needs while maintaining preselected adjustable pressure. Pump includes an



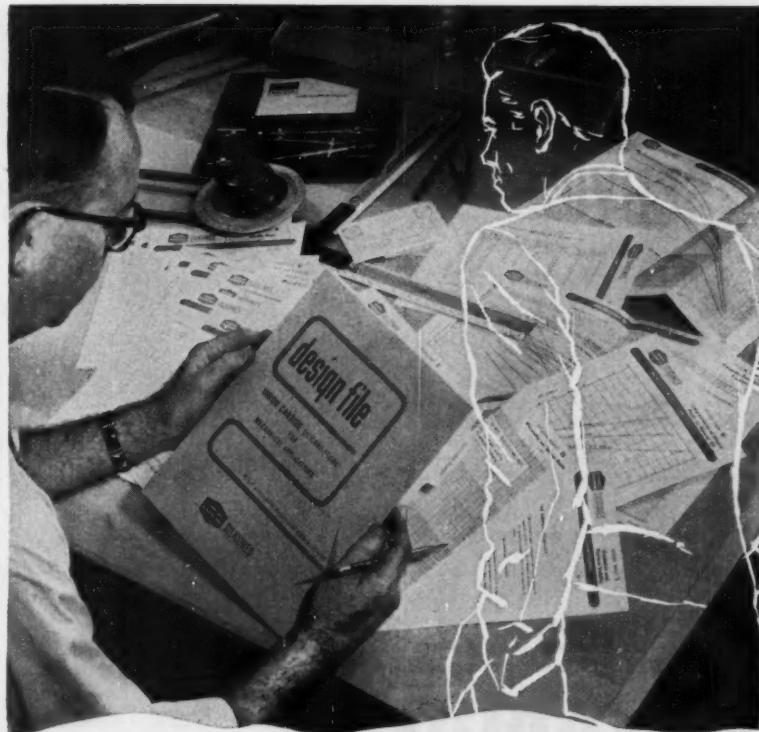
integral pressure compensator that can be set for 200 to 500-psi operation. Maximum delivery can be limited by means of a mechanical adjustment. Sharp cut-off characteristics enable pump to deliver nearly full volume up the compensator setting, even at low operating pressures. Unit operates with 1800-rpm electric motors. It is available for flange, foot, or gasket mounting. **Vickers Inc., Div., Sperry-Rand Corp.**, Detroit 32, Mich.

**Circle 790 on Page 19**

### Snap-Acting Switch

provides split-contact,  
SPDT operation

Type BK-1 enclosed snap-acting precision switch combines versatility in circuit control with high safety factor in heavy-current dc circuits. It provides split-contact, SPDT operation. Switch is sealed within a cast-aluminum housing and is actuated through a high-pressure spring plunger having a scraper that removes ice, dirt, or other deposits. Switch can be rated at 10 amp, 125/250 v ac. It withstands damp, dusty, or corrosive atmos-



### GET THIS NEW DESIGN AID FROM THE SILICONES MAN "MOST USEFUL REPORT ON . . . SILICONE FLUIDS YET PUBLISHED"

Here's an up-to-date design file on UNION CARBIDE silicone fluids for mechanical applications that you'll find invaluable. Assembled by your Silicones Man, it's the most thorough and useful set of engineering properties of silicone fluids yet published.

Actually a working tool, it includes data sheets on viscosity-temperature properties, apparent viscosity vs. shear rate, compressibility, oxidative and thermal stability, lubricity, thermal expansion. Other sheets are devoted to corrosion, specific heat, density, compatibility, and to shipping, handling and storage data.

It's invaluable for designing shock absorbers, gyroscopes, hydraulic systems, damping devices, liquid springs, valve tappets, and many other components. New material not available elsewhere includes viscosity-shear relationship of dimethyl oils at shear rates above 10,000 reciprocal seconds. For your copy, just send the coupon. Silicones Division,

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## COST AND SERVICE STORY

**behind Reese Powdered Metal Knobs for Bernz-O-Matic Ceramic Grill**

From John B. Spiggle, Purch. Agent for the Otto Bernz Co., Inc.: "Our present brass powdered metal knob was evolved from a smaller knob that was re-designed from a screw machine part to reduce cost. When we required a larger but similar knob on another product, we immediately thought of powdered metal. Reese received the order for this new part because their price and delivery were better than others who had quoted. We have continued to do busi-

ness with Reese because their prices have been in line and their service and quality better than our other sources for powdered metal parts."

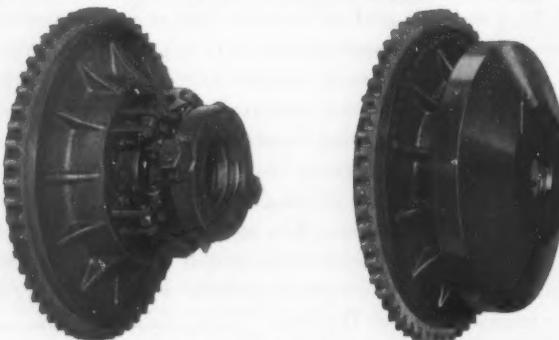


FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.



Circle 581 on Page 19

## Make Your Choice Of Clutch While Your Equipment Is In The Design Stage . . .



You can have your machine equipped with either our Over-Center Friction Clutch (left) or our Air-Operated Clutch (right). Each has its advantages depending on the use of the equipment. These clutches come in a wide range of sizes and with gear tooth or Flex-Disc. All are high quality, dependable clutches having low power losses, low upkeep, and long life. Readily adjustable for lining wear. Send for bulletins 5009 (Over-Center), 5011 (Air-Operated), or 5012 briefing our entire line of industrial clutches.

**INDUSTRIAL CLUTCH CORP.**

Waukesha  Wisconsin

## NEW PARTS AND MATERIALS



pheres. Switch is  $2\frac{1}{8}$  x  $13/16$  x  $2\frac{11}{32}$  in. over-all and weighs 3 oz. Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.

Circle 791 on Page 19

## Molding Compound

has heat distortion point of over 500 F

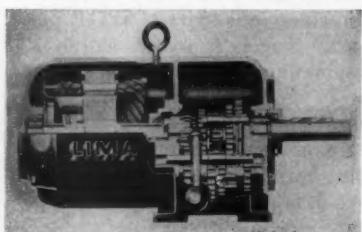
Designated RX 495, asbestos-reinforced phenolic molding compound is available for gears, electrical switchgear, and control parts. Featuring a heat distortion point of over 500 F, compound combines an impact strength of 12,000 psi, tensile strength of 6000 psi, and compressive strength of 22,000 psi. Affording a low bulk factor for this class of material, phenolic molds to a high luster finish with a mold shrink of only 0.001 in. per in. Rogers Corp., Rogers, Conn.

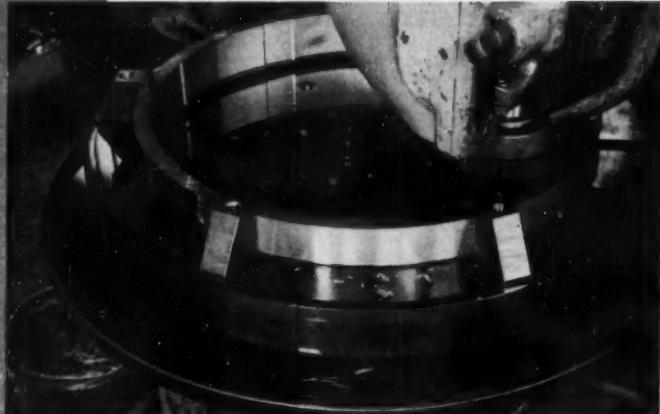
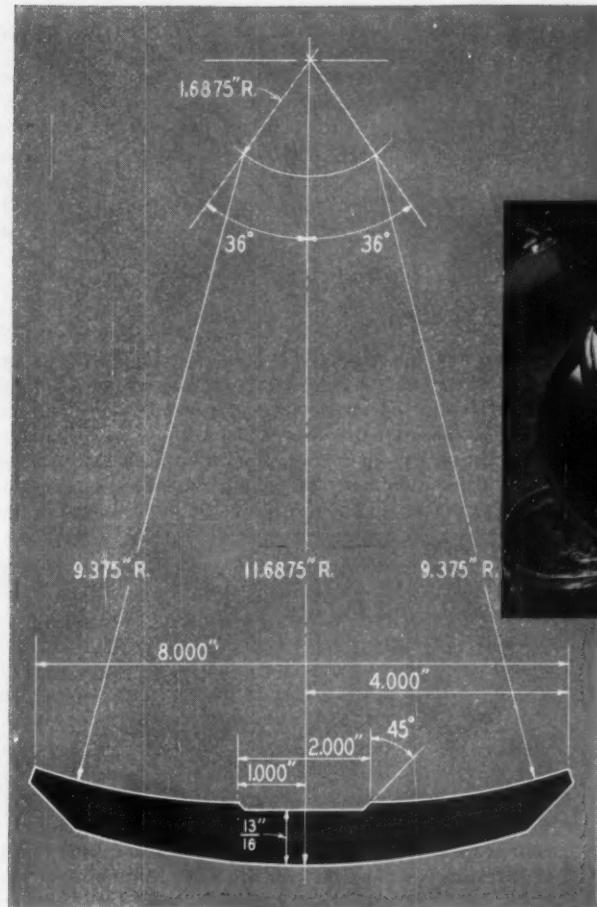
Circle 792 on Page 19

## Gearshift Drive

mounts in any position

Type R3 selective four or eight-speed gearshift drive, redesigned internally, is available for mounting in any position. Design changes also include: Stress-proof steel shafting in motor and gearbox, with hardened splines on spline shaft for extreme service requirements and long life; lifetime sintered bushings on countershaft bearings; double-width sealed and lifetime-lubricated ball





## 2 RADII, 3 SURFACES Cut in One Operation

Difficult machining job? Shop management at Blanchard Machine Company, Cambridge, Mass., made it a simple production operation using a standard Fellows Gear Shaper. Eight of these segments are shaped at one time, as shown in the photograph. A special gear shaper cutter generates all of the internal surfaces in one revolution of the work table. The segments are then simply cut apart, drilled and tapped. The pieces are segment clamps to hold grinding wheel sections in

the chuck of the Blanchard Surface Grinder. The same Fellows Gear Shaper, using appropriate cutters, can produce an almost infinite range of non-circular shapes, simple or complex, as well as internal and external spur, helical and herringbone gears, and gears close to shoulders or in recesses. The advantages of the Gear Shaper are illustrated in "The Art of Generating with a Reciprocating Tool." If you would like a copy just write us.

**THE FELLOWS GEAR SHAPER COMPANY**  
78 River Street, Springfield, Vermont

**Branch Offices:**

1048 North Woodward Ave., Royal Oak, Mich.  
150 West Pleasant Ave., Maywood, N. J.  
5835 West North Ave., Chicago 39, Ill.  
6214 West Manchester Ave., Los Angeles 45, Cal.



THE  
PRECISION  
LINE

**Fellows**

Gear Production Equipment

**"Sure it's a great idea  
but we were  
only using 26% of it!"**



"We've had the Payroll Savings Plan for U.S. Savings Bonds in our outfit for years. We think it is good for the Country and good for our company—and it goes without saying it's good for the saver. I had assumed we had a large participation by our people. But when I checked up last month I found that only 26% of our employees were regular users of the plan. In a company our size there is always a certain amount of personnel turnover, and there are always some people who are going to subscribe . . . next payday, maybe."

"So what I did was contact our State Savings Bonds Director. He helped us put on a company-wide campaign that reached every employee personally to point out the advantages of buying new 3 1/4% Savings Bonds, *regularly*. Today we have more than 50% of our people using the plan, and we're going on from there!"

Perhaps *your* organization, too, has been taking your Payroll Savings Plan for granted. It's a great idea, but its value to your people and to your company increases with the number of employees who use it, *every payday*. Let your State Savings Bonds Director show you how easy it is to get your company back in the high value area of participation. Or write Savings Bonds Division, U.S. Treasury Department, Washington, D.C.



**ALL U.S. SAVINGS BONDS—OLD OR NEW—EARN  $\frac{1}{2}\%$  MORE THAN BEFORE**



**MACHINE DESIGN**

THE U. S. GOVERNMENT DOES NOT PAY FOR THIS ADVERTISEMENT. THE TREASURY DEPARTMENT THANKS, FOR THEIR PATRIOTISM, THE ADVERTISING COUNCIL AND THE DONOR ABOVE.



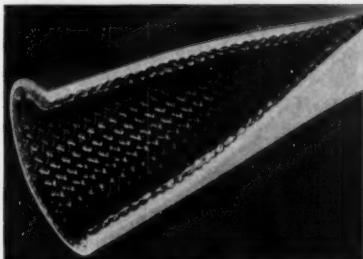
## NEW PARTS AND MATERIALS

bearings replace single-width bearings on output shaft and motor shaft. Pressure-tight seals assure leakproof operation when drive is specified for vertical mounting. Type R3 is furnished with standard single-speed motors of 1800, 1200, or 900 rpm. Ratings of 1, 1½, 2, 3, and 5 hp are available. Drives operate on standard 208, 220/440, or 550-v, three or two-phase, 60-cycle current supplies. Lima Electric Motor Co. Inc., Dept. 139, Lima, Ohio.

Circle 793 on Page 19

### Insulating Sleeving

expands four sizes larger than original diameter



Extrusion-coated, silicone-rubber insulating sleeving, with basic braid of inorganic glass fiber, is called Ben-Har 1151. Durasyl silicone rubber is highly resistant to abrasion, eliminating fingernail damage and similar product assembly hazards. Sleeving expands four sizes larger than its original diameter, fitting easily over irregular connection without end fray or coating fracture, and recovers shape indefinitely. Snug fit eliminates vibration. Sleeving meets specifications for electrical insulating sleeveings covered by MIL-I-18057A and NEMA Type 5. It is rated for continuous operation at 220 C, and low-temperature brittle point is below -85 C. It is made in even-numbered AWG sizes 24 to 8, and in all AWG sizes 8 to 5/8 in. Bentley-Harris Mfg. Co., Conshohocken, Pa.

Circle 794 on Page 19

### Wafer Capacitors

have capacitance range of 1 to 10,000 mmf

High-temperature solder-wire leads are available on five sizes of glass-dielectric wafer capacitors to provide a capacitance range of 1 to

## NEEDED: VIBRATION ISOLATION AT BOTH HIGH AND LOW FREQUENCIES



A mount soft enough to isolate vibration in the upper range of frequencies generally gives trouble with a low natural frequency. With sensitive precision equipment, such as airborne sighting mechanisms, for example, a mount must work at both ends of the frequency spectrum.

## ANSWER: MB ISO-DAMP MOUNTS CONTROL FULL FREQUENCY RANGE



Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give the MB Isomode Mount its high frequency isolation efficiency in any position. In the low range, a unique damping mechanism effectively restricts resonant build-up; does not affect high frequency isolation. Unit also meets MIL-E-5272-A shock requirements.

## WHAT'S YOUR MOUNT PROBLEM?



Iso-Damp mounts can be modified to meet your particular requirements. Or possibly one of MB's other standard mounts may be the answer to your special vibration control problem. Why not let MB's experienced specialists help find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

## MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.  
1056 State Street, New Haven 11, Conn.

## Odd shapes are no problem for the new Townsend Model 75 Tubular Rivet Setting Machine

High production rates  
using unskilled labor  
cut fastening costs



Skillfully designed tooling gives complete versatility to the new Townsend Model 75 Tubular Rivet Setting Machine. A variety of specialized tooling is available to equip the Townsend machines for any size and shape of work.

Townsend tubular rivets are available in steel, aluminum, copper, brass, nickel-silver and special materials for use in joining anything from cloth to steel sheets. Thus, Townsend makes available the economies of tubular rivet fastening for a wide range of products in a number of different materials. Townsend's experienced fastening engineers provide application design service.

To enjoy the economies of fastening with tubular rivets, write for information on Model 75 Setting Machine and complete line of Townsend tubular rivets. Townsend Company, Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pa.

### Townsend Company

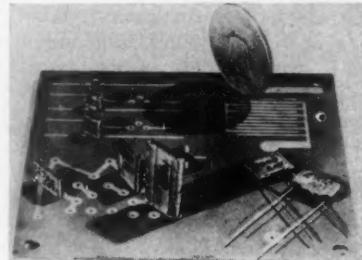
ESTABLISHED 1876

#### Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

Dunlap Steel Division • Santa Ana, California

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario



10,000 mmf—ten times higher than previous units. Largest size, WL-1, requires only 0.061 sq in. on a printed-circuit board and weighs only 2.5 grams. Capacitance range of the WL-1 is 4301 to 10,000 mmf. All wire leads are 3/16 in. long. Working voltage is 300 v, and operating temperatures are -55 to +125 C without derating. Capacitors meet operating requirements of MIL-C-11272A. Electronic Components Dept., Corning Glass Works, Bradford, Pa.

Circle 795 on Page 19

### Polyester Laminate

for structural components  
of electrical apparatus

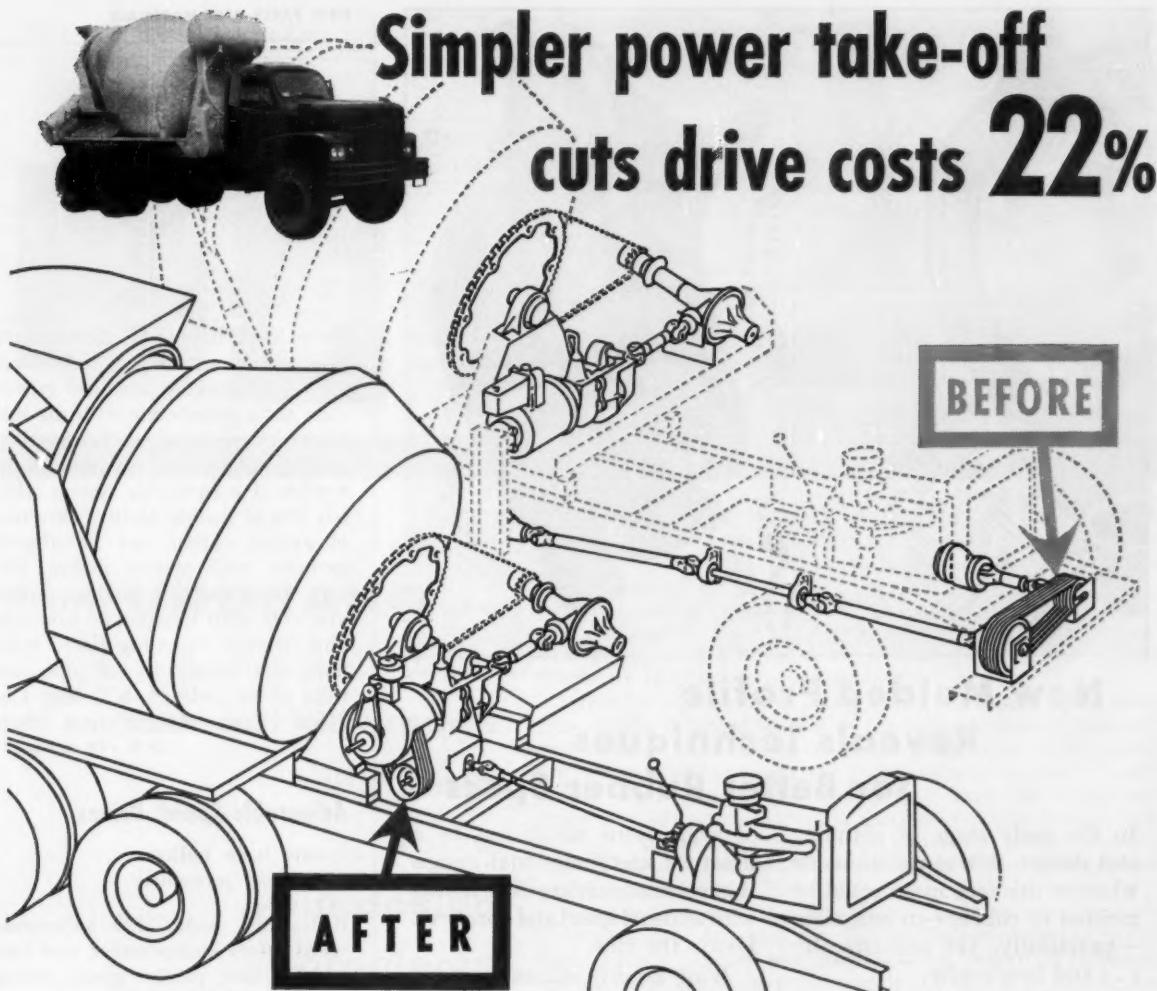
Glass-mat-reinforced Micarta polyester laminate for use in electrical apparatus resists deterioration by flame, moisture, arcing, leakage currents, and impact. Good physical properties are retained when heated to 130 C. Material exceeds NEMA GPO-1 performance requirements for plastic laminates. It is available as thick plate, angles, or sheets, and in other shapes by special order. Monolithic plates without glue line are available in thicknesses to 2 in. and in rectangular shapes to 36 in. square. Angles to 60 in. long are available in 1/8-in. material, and to 40 in. long in 3/16-in. material. Sheets are red or brown, 36 in. wide, range in length from 36 to 72 in. and in thickness from 1/8 to 5/8 in. Micarta Div., Westinghouse Electric Corp., Hampton, S. C.

Circle 796 on Page 19

### Hydraulic Fittings

withstand high  
working pressures

Flanged hydraulic tube and pipe connection fittings of welded ma-



Super HC V-Belts—packing higher hp capacity in smaller space than conventional V-belts—have eliminated need for front-end power take-off on concrete-mixer trucks made by Concrete Transport Mixer Company of St. Louis, Mo.

By letting take-off be shifted to rear, Super HC V-Belts cut drive costs alone by 22%, besides saving weight and cost of complex linkage and

other components of the former front-end drive.

With Super HC, sheave diameters can be cut 30% to 50%, drive space up to 50%, and drive weight 20% and more. A product of Specialized Research in the world's largest V-belt laboratories, Super HC V-Belts are helping many manufacturers put more compact, lighter weight, lower cost drives on all types of machines.

#### Engineering Service Nation-Wide

What's your power transmission design problem? Your Gates Field Representative is ready to help you solve it—to cut space, weight, cost with Super HC V-Belt Drives. Ask

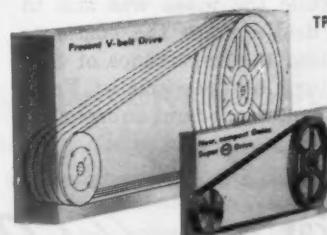
him for your free copy of "The Modern Way to Design Multiple V-Belt Drives" or write The Gates Rubber Company Sales Division, Inc., Denver, Colorado.

**The Gates Rubber Company, Denver, Colorado**

Gates Rubber of Canada Ltd., Brantford, Ontario



World's Largest Maker of V-Belts



**Gates Super HC V-Belt Drives** same hp capacity  
in smaller "package"



Courtesy Scott Aviation Corp.

## New Molded Profile Reveals Techniques for Better Rubber Specs

In the early stage of planning and design, it was questionable whether this face mask could be molded in rubber—in one piece—practically, yet economically . . . and here's why.

It calls for an ingeniously designed and machined mold to provide for facial contours, air inlets and outlets, undercuts, feathered edges, valve mounts, fastenings, etc.—one of the hardest-to-fill cavities ever encountered. Also, the rubber must be compounded to flow freely inside this complicated form and still maintain its knitting qualities. How was this accomplished?

While the mask was still in the design stage the customer realized the importance of consulting a rubber specialist. From this conference came an exchange

of suggestions which led to a practical and functional design that permits molding these masks with unusual speed and economy. Here's the idea.

*While a job is still on the drawing board consult with rubber specialists. Suggestions can often be made to eliminate high tooling costs or high priced compounds. End results give you better rubber parts, better performance and lowest cost. Regardless of how simple or complex your rubber needs may be call Continental—specialists since 1903.*

### Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

*Another achievement in RUBBER  
engineered by CONTINENTAL*

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

## NEW PARTS AND MATERIALS



chine steel have SAE bolt-spacing design and an O-ring seal. They withstand working pressures greater than those permissible with the tubing or piping involved. Connections permit quick assembly and disassembly of a hydraulic system without loss of sealing ability. Direction of angled outlets can be aligned perfectly with system piping. Picture shows various standard outlets available with flange-type tube and pipe fittings, including flared tube, male and female dryseal pipe, and weld socket styles. L & L Mfg. Co., 21590 Hoover Rd., Warren, Mich.

Circle 797 on Page 19

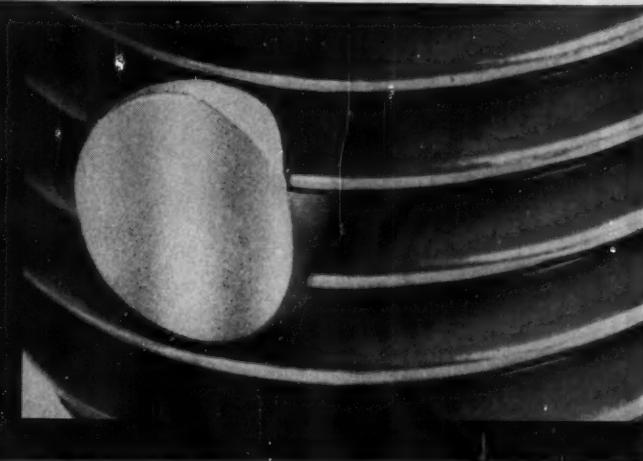
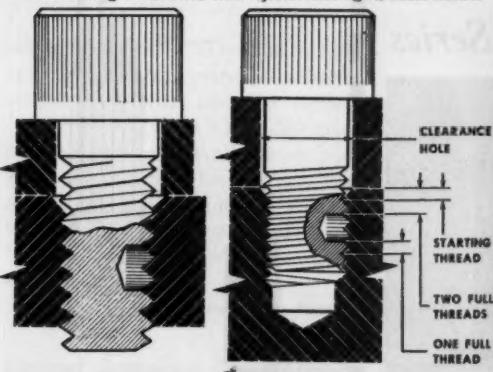
## Adjustable-Speed Drives

now have built-in overload protection

Redesigned Series 400 adjustable-speed drives incorporate a new control for fast, precise speed setting, and have built-in overload protection. Other features include a larger input shaft on smaller models for easier adaptation of pulleys and accessories, wider mounting pads and double-slotted holes for greater stability and easier alignment, up to 40 per cent decrease in heat rise over ambient, improved gasketing and oil seals, and nonheat-conducting control knobs. Relocation of oil drain, level, and filler-breather holes permits mounting the units in any position. Control lever mounts in four positions to suit convenience of operator. Drives provide infinite speed control, and have output



Self-locking UNBRAKO with Nylok locks tight, seals fluids.



**From UNBRAKO...  
major  
fastener advances  
that help  
solve  
your design  
problems**

Fasteners that are inherently stronger and that can be tightened tighter help solve your design problems because you can specify fewer of them or smaller diameters. UNBRAKO is a case in point.

Among recent UNBRAKO design advances are its socket head cap screw pHd\* head and its Hi-Life thread. The pHd head provides up to  $2\frac{1}{2}$  times as much holding power, the Hi-Life thread up to 100% longer fatigue life.

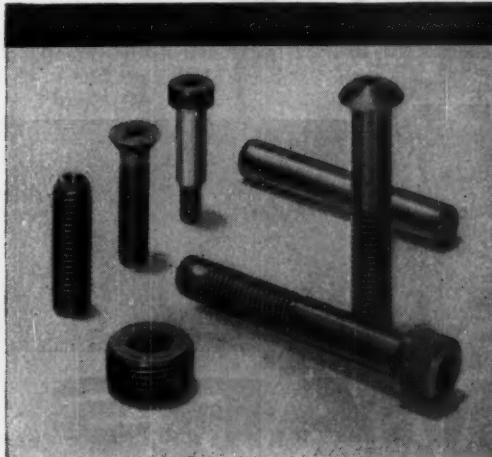
Other UNBRAKO pluses: Nylok,† which utilizes a nylon pellet fixed in the threaded section of the screw to make UNBRAKOS self-locking . . . a deeper, more accurate socket that assures uniform wrenching power for high maximum torques . . . controlled head-to-shank fillet and forged head for continuous grain flow to increase strength and resistance to fatigue failures . . . the self-locking knurled cup point, which prevents High Torque UNBRAKO socket set screws from working loose even in poorly tapped holes.

Your authorized SPS distributor carries the complete UNBRAKO line. See him for further information—or write SPS, manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Request Bulletin 2338, describing the UNBRAKO line.

PRODUCT	Standard UNBRAKO Screw Products	DIAMETERS
Socket Head Cap Screws	.....	#0 to $1\frac{1}{2}$ in.
Socket Set Screws	.....	#0 to 1 in.
Flat Head Socket Screws	.....	#0 to $\frac{3}{8}$ in.
Button Head Socket Screws	.....	#0 to $\frac{3}{8}$ in.
Shoulder Screws	.....	$\frac{1}{4}$ in. to $\frac{3}{8}$ in.
Dowel Pins	.....	$\frac{1}{8}$ in. to 1 in.
Pressure Plugs	.....	$\frac{1}{8}$ in. to $1\frac{1}{2}$ in.

Stainless steel cap and set screws are stock items. All other UNBRAKO products are available in stainless steel on order.

\*pHd stands for "proper head design" (1960 series)—a factor in higher product reliability  
†T.M. Reg. U.S. Pat. Off., The Nylok Corporation



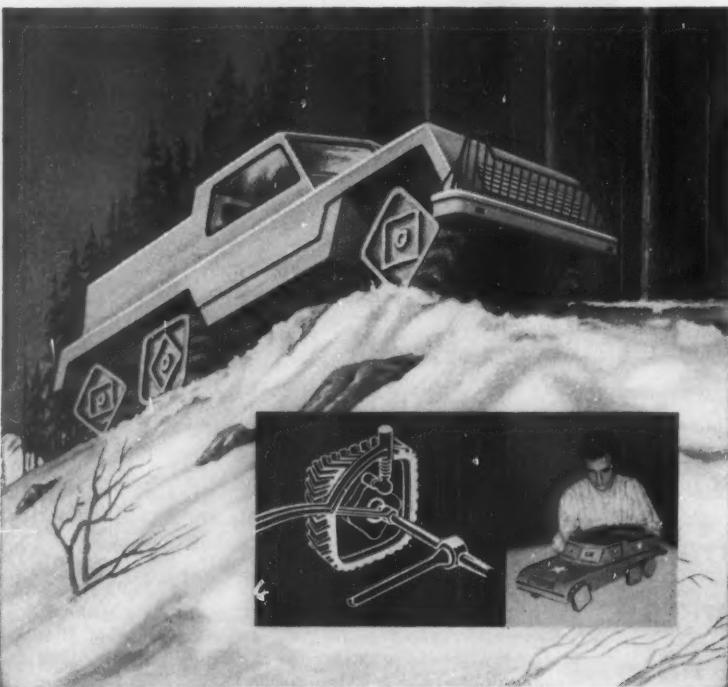
**INDUSTRIAL FASTENER Division**

JENKINTOWN 18, PENNSYLVANIA

**SPS**

where reliability replaces probability

## No. 14 • Mars Outstanding Design Series



**SQUARE WHEELS?** Yes ... square wheels. Operating by means of a floating axle and cam gear, they take the bumps out of rough terrain and provide more traction. U.S. Patent No. 2786540 has been granted to designer Albert Sfredda of Bethlehem, Pa., for his invention.

The square shape gives superior traction in mud, sand, snow or uneven terrain. The flat surfaces of the wheels bridge the ruts instead of sinking into them as do round wheels. The wheels can be in any relative position, do not need to be synchronized—yet they run smoothly. Designed for use on heavy trucks, jeeps, farm or construction machinery, speeds up to 35 miles per hour can be attained.

This ingenious departure from age-old precedent is just one example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality they require the best of drafting tools.

*In pencils that means MARS, long the standard of professionals.*

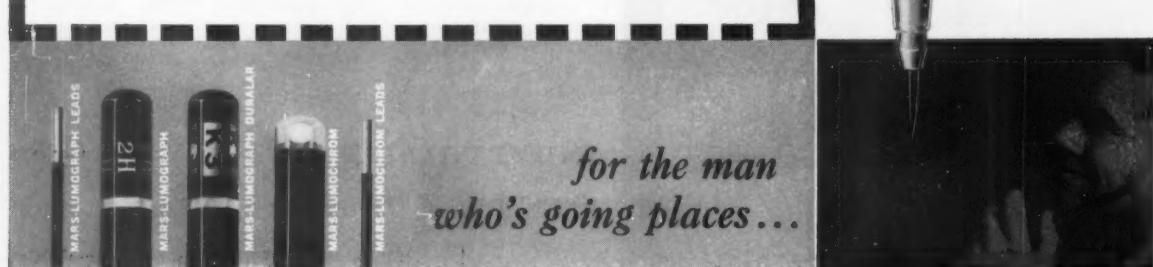
2H  
1001 J.S. STAEDTLER MARS-LUMOGRAPH TECHNICO



Among the famous imported Mars drafting products are:  
Left — 1001 Mars-Tecnico push-button lead holder.  
Above — 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. Below — 2886 Mars-Lumograph drawing pencils, 19 degrees, EXXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film — 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. Not shown — Mars Pocket-Tecnico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

©T.M. FOR duPONT'S POLYESTER FILM



*the pencil that's as good as it looks*

# MARS

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

range from 0 to 1200 rpm with 1800 rpm input. Unit provides smooth, stable drive with constant torques from 3 to 450 lb-in. Over 250 models and types are available with or without fractional-horsepower motors from  $\frac{1}{8}$  to  $\frac{1}{4}$  hp and with or without reverse or gearhead. Zero-Max Co., 1900 Lyndale, S., Minneapolis 5, Minn.

**Circle 798 on Page 19**

### Current Sampling Transformers

for use with devices which develop high pulse currents

IST series of seven-pulse current sampling transformers delivers synchronizing voltage pulses for use with radar transmitters or other devices which develop high pulse currents. Voltage pulses have same shape as high current pulses. No resistance is added to circuit because transformer is not connected to current carrying the conductor; voltage pulses are developed by passing conductor through hole in transformer. This approach eliminates bulky resistive networks. Size is  $9/16 \times 1\frac{1}{2} \times \frac{3}{8}$  in. and weight is  $\frac{1}{8}$  oz. Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

**Circle 799 on Page 19**

The following story, run in our Feb. 4 issue, contained several incorrect figures. Correct item is presented below.

### Compact Pumps

are lightweight, compact, motor-mounted units

Compact, motor-mounted Viking 656 pumps are light in weight. Typical applications are for pressure lubrication, filtration, circulation, and transferring of liquids up to 7500 SSU. Built with steel-fitted, bronze-fitted, or all-bronze construction, the new pumps include  $\frac{1}{2}$ ,  $1\frac{1}{2}$ , and 3-gpm sizes. Mechanical seals or conventional packing are optional. Units are available with  $\frac{1}{4}$ ,  $\frac{1}{3}$ ,  $\frac{1}{2}$ , or  $\frac{3}{4}$ -hp, single-phase, 1750-rpm motors—open or explosionproof type. All sizes use the same mounting-flange bracket. Viking Pump Co., Cedar Falls, Iowa.

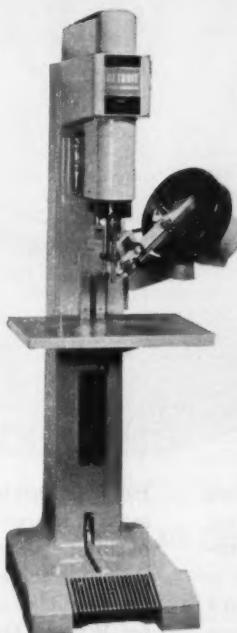
**Circle 800 on Page 19**

How many →  
what's  
your  
guess?

Screws are  
#8-32 x  $\frac{1}{2}$  inch long.



*One man can drive them in one hour*



The new DPS Model U screwdriving machine.



## with a DPS power screwdriving machine

Why sacrifice manpower on so simple yet tedious a job as driving screws? Free skilled hands for more productive work . . . get higher output per happier manhour—with a DPS power screwdriving machine.

To illustrate, one worker can drive the 2,400 screws in the jar above in one hour. And with no more effort than pressing an air-operated foot pedal. Equally important, they're driven through an easily adjustable clutch, designed to hold constant driving torques.

**NEW! THE MODEL "U"**—At left, meet the great, new DPS Model "U" screwdriving machine—quickly adaptable for fast, clean driving of screws, nuts and studs. New folder contains full data. Write for your copy today.

19-048



### DETROIT POWER SCREWDRIVER COMPANY

2801 W. Fort St. Detroit 16, Michigan  
A Subsidiary of Link-Belt Company

# Everything new but the shape



Ever since man discovered the wheel, he has been working at new ways to use it. The latest use of the wheel is in the jet turbine. These turbine wheels and compressor wheels, forged in massive closed dies from materials unknown a few years ago, make possible the outstanding performance records of our American engines.

Helping wheels turn—on the ground—on the sea—in space—is all part of Wyman-Gordon's business. Where performance depends upon stamina, there is no substitute for a forging—and in a forging there is no substitute for Wyman-Gordon experience, quality and dependability.

## WYMAN - GORDON FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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FRANKLIN PARK ILLINOIS

LOS ANGELES CALIFORNIA

FORT WORTH TEXAS

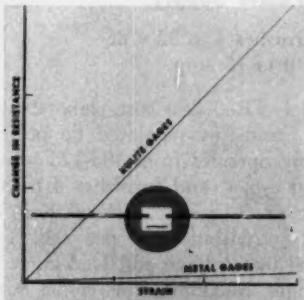
ENGINEERING  
DEPARTMENT

# EQUIPMENT

## Strain Gage

has gage factor  
of 115 at 70 F

Kulite semiconductor strain gage, Type DA-101, has a nominal resistance of 70 ohms and gage factor of 115 at 70 F. Over-all dimensions are 5/16 x 1/2 in. Complete with rugged nickel leads, it is for use in the same manner as existing metal wire and foil gages. Maximum al-



lowable strain is 1500 microinch per inch, and maximum operating temperature is 800 F. Graph shows resistance change as compared to existing metal gages. Kulite-Bytrex Corp., 50 Hunt St., Newton 58, Mass.

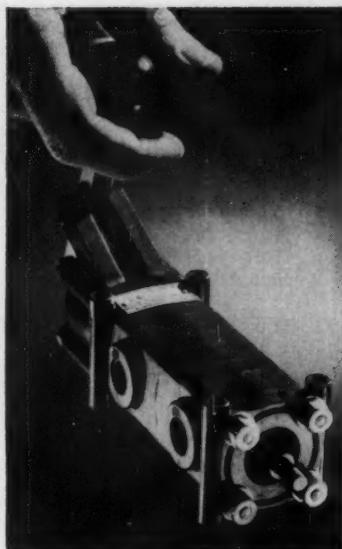
Circle 801 on Page 19

## Surface-Temperature Indicator

is adhesive-backed  
plastic label

Calibrated to give an irreversible registration of temperature, Temp-Plate plastic label is currently available for indication of temperatures from 100 to 700 F in a choice of 50 increments, with tested indication accuracy of  $\pm 1$  per cent. Label, backed with adhesive for simple application, registers a permanent change from white to black as stated temperature level is reached. It adheres to mounting surface under a wide range of exposure conditions until intentionally removed. Developed to detect overheating or

# Typical Control Functions solved by AIR CIRCUITRY



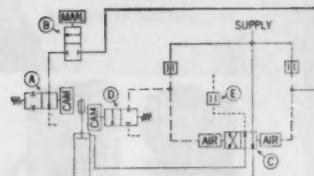
Westinghouse Type "D" Pilotair Valve

Another of Westinghouse Air Brake's many AIR CIRCUITRY components, the "D" PILOTAIR® Valve is a spool-type directional valve that can be operated by a lever, button, cam, solenoid, air pilot, pedal or treadle. Valves available in two, three, and four-way operation, two and three position, open neutral, lap neutral and vented neutral. Port sizes are 1/4" and 1/2" ips. Operators may be on either or both ends. Max. operating pressure: 250 psi.

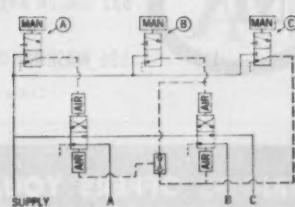
**DESIGN FEATURES.** A new design of seal and segment construction gives the "D" PILOTAIR® Valve increased capacity and requires a minimum of maintenance. By rotating operators, their mounting brackets and any of their ports in 90° steps, over one-hundred thousand combinations may be obtained. They operate in any position with air, gas, water and most oils. The "D" PILOTAIR® Valve can satisfy any of your directional valve needs. For more information, ask for catalogue A4-75-01.

## What is AIR CIRCUITRY?

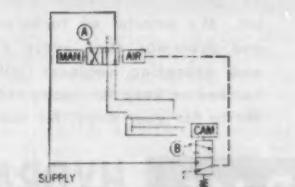
This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise Air Circuitry is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will boost production and cut costs.



**1. AUTOMATIC CYCLING**—Supply air flows to the cylinder to extend the cylinder rod and actuate cam operated valve "A." By operating valve "B" air is bled from the right-hand air pilot of valve "C" to operate this device and retract the cylinder rod. This actuates valve "D" and reverses the process. Cycling time may be changed by regulating the FLOREG® valve "E." The stroke is set by moving the cams on the cylinder rod.



**2. STATION TRANSFER**—Any of the three stations may capture supply air for the station by operating its respective valve. This may be expanded to any number of stations.



**3. AUTOMATIC RESET**—To reset the operating valve "A" after completion of an operation. Moving the manual operator admits supply air to the cylinder to extend its rod. At the end of the cylinder rod stroke cam operator valve "B" is actuated to connect supply air to the air pilot operator of valve "A." This returns this valve to its original position. Supply air is then connected to the cylinder to retract the cylinder rod. The circuit is now ready for re-cycling.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor



**WESTINGHOUSE AIR BRAKE COMPANY**  
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

FOR INSTANT SMOOTH STEPLESS CONTROL

## MAGNE-SPEED VARIABLE SPEED DRIVES

CONSTANT TORQUE OVER ENTIRE SPEED RANGE  
RANGE OF ADJUSTMENT ZERO TO FULL SPEED

JUNIOR:

1/6 to 1/100 HP  
40:1 speed range  
request bulletin S-790



SIZE I:

1/4, 1/2 and 1/2 HP  
50:1 speed range  
request bulletin S-580



SIZE II:

1/4, 1 and 1 1/2 HP  
50:1 speed range  
request bulletin S-580



## MAGNETIC AMPLIFIERS, INC.

632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610

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Circle 595 on Page 19



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FLUID CIRCUITS AND HYDRAULIC  
OIL FILTRATION

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It's brimful of technical data  
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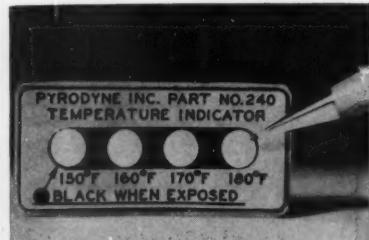
NAME \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_



ENGINEERING DEPT. EQUIPMENT



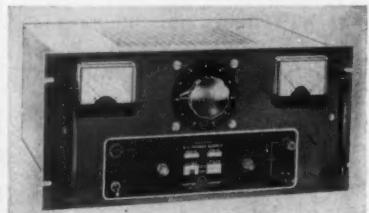
hot spots on wing surfaces, nozzles, tubing, valves, brakes, radar panels, and other critical points where excess temperature presents a hazard, plates eliminate cost, installation, and maintenance problems of more complex temperature-recording devices. Pyrodyne Inc., 11973 San Vicente Blvd., Los Angeles 49, Calif.

Circle 802 on Page 19

## DC Power Supply

furnishes 4 to 32 v dc  
at 0 to 15 amp

Model TR40 low-cost, laboratory-type, transistor-regulated dc power supply operates from 105-125 v ac, 50-60 cycles, and furnishes 4 to 32 v dc at 0-15 amp. Regulation is held to within  $\pm 1/2$  per cent for stated line voltage and load current changes. Maximum rms ripple does not exceed 2 mv. Panel controls include power switch, main voltage control, vernier voltage control, line



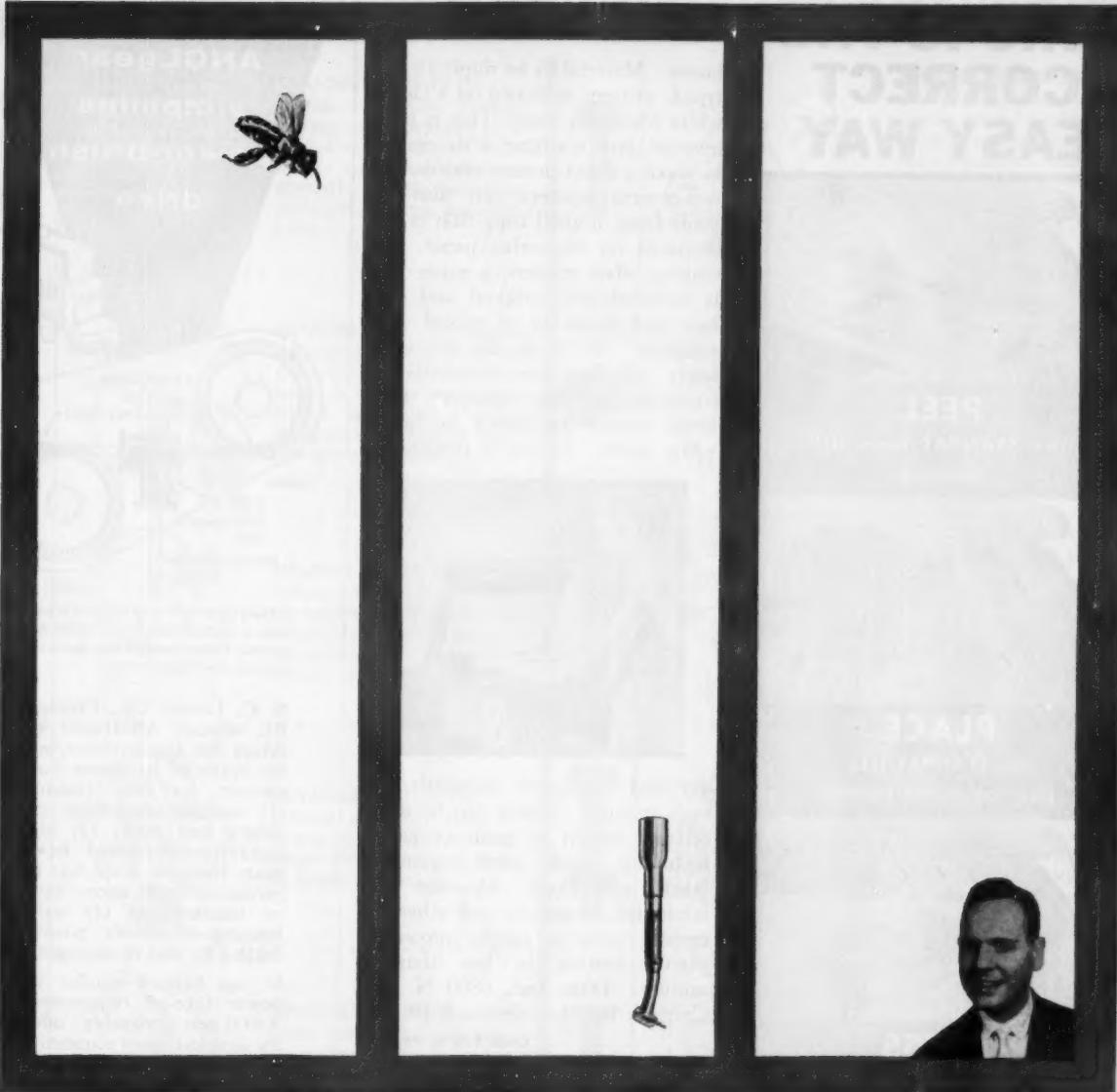
and load fuses in indicating-type fuse holders, and dc voltmeter and ammeter. Unit is intended for rack mounting and occupies only 8 3/4 in. of vertical panel height. Opad Electric Co., 43 Walker St., New York 13, N.Y.

Circle 803 on Page 19

## Copying Machine

also laminates documents  
with plastic coating

Masterfax machine makes direct (spirit) process masters, offset masters, facsimile copies, and it lam-



**A Tiny Producer.** the honeybee, is equally famous as a supplier of a favorite delicacy and as a pollinator of valued crops. Worker bees — the only nectar-gatherers, honey-processors and home-builders — are always the smallest members of their colony. About  $\frac{1}{2}$ " long, they're considerably smaller than drones.

**Small Pain-Reducer.** In this newest dental handpiece, tiny MPB bearings permit the head to be miniaturized for easier use and better visibility, particularly with children. The MPB bearings used here must withstand punishing acceleration from 0 to 250,000 rpm in a half-second, the speed necessary for comfortable, quiet drilling.

**Man With Miracles.** Every day MPB Sales Engineer Ray Armstrong helps industrial and scientific engineering staffs to select miniature bearings that reduce friction and increase accuracy of instruments and other devices. An MPB sales engineer is always ready to help you develop the miniaturization your products need.

## Miracles in Miniaturization

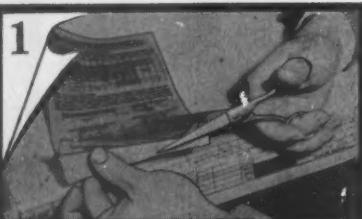
ACTUAL SIZE OF THE MPB BEARING  
IN DENTAL HANDPIECE SHOWN ABOVE

**More Miniaturization Than Ever.** Even in the dimmest past, reductions in size have been absolute necessities to meet certain needs. Today, outer space exploration and many other modern projects call for miniaturization on a greater scale than ever. MPB, continuing as the foremost pioneer in this field, produces over half of the nation's supply of miniature bearings, including over 500 types and sizes, ranging down to  $1/10$ " O.D., with specials as required. For a catalog with complete details, for engineering assistance or for both, write

Minature Precision Bearings, Inc., 103 Precision Park, Keene, N. H.

**MPB** Helps you perform  
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## PEEL

the STANPAT from its  
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the STANPAT into  
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**Don't chain your engineers to time-consuming routine on repetitive blueprint items . . . free them for more creative work and save countless hours of expensive drafting time with STANPAT.**

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Please quote on enclosed samples.  
 Kindly send me STANPAT literature and  
samples. Dept. 169

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_

Circle 598 on Page 19

## ENGINEERING DEPT. EQUIPMENT

inates. Material to be duplicated is typed, written, or drawn on a clean, white Masterfax sheet. This is then inserted into machine with carbon to make a direct-process master. Direct-process masters can also be made from original copy that is not prepared on Masterfax paper. In making offset masters, a paper mat is included with original and carbon and assembly is placed into machine. In 15 sec the master is ready to reproduce hundreds of copies on any offset machine. Facsimile copies are black on plain white paper. Process is completely



dry and eliminates chemicals and toxic mixture. Copies can be made on any weight or grade of paper, including card stock, gummed labels, and cloth. Machine also laminates documents and other literature with a tough, protective plastic coating in less than a minute. Ditto Inc., 6800 N. McCormick Rd., Lincolnwood, Ill.

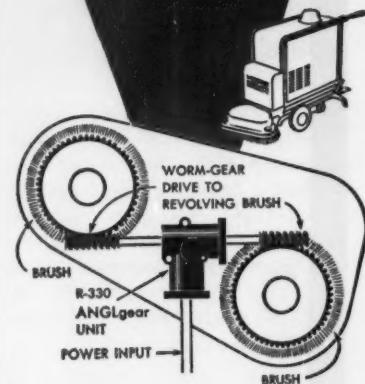
Circle 804 on Page 19

## Transparent Adhesive Film

is furnished blank or with  
symbols for application

Dulseal transparent adhesive film is 0.0015-in. acetate furnished in blank sheets and rolls, or printed with material used repeatedly on drawings, such as symbols and wiring diagrams. Delayed setting action facilitates accurate positioning and allows material to be relocated several hours after original application, if necessary. Material is also an excellent mending tape for torn drawings, and is available in narrow rolls for this purpose. It is washable, waterproof, and chemically stable. Matte outer surface allows use of pen, pencil, or typewriter, and surface takes repeated erasures with no reduction in clar-

**ANGLgear**  
simplifies  
power-brush  
drive



Cutaway shows use of  $\frac{1}{2}$  hp ANGLgear in brush head of LAWLRmatic 26 in. electric floor scrubber. Company employs ANGLgear in several of its other models as well.

S. C. Lawlor Co., Chicago, Ill., selected ANGLgear  $90^\circ$  drives for the scrubber/buffer heads of its power floor cleaners for these reasons: (1) compactness—helps cut weight and bulk; (2) high capacity—hardened bevel gears transmit more hp; (3) permanent lubrication—saves on maintenance; (4) sealed housing—eliminates possible fouling by wax or detergents.

If you have a similar  $90^\circ$  power take-off requirement, ANGLgear probably offers the simplest, most economical solution. Available immediately from stock, these standardized right-angle drives are easily incorporated in your power transmission systems\* because of their compactness and universal mounting feature.

\*Design templates free on request

You can specify  
ANGLgear in  $\frac{1}{2}$ , 1,  
 $2\frac{1}{4}$  and 5 hp ratings  
with 1:1 or 2:1  
gearing and 2 or 3  
way shafting. See  
Sweet's Product  
Design File or our  
local distributor.



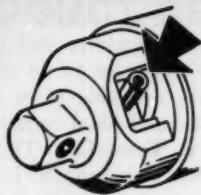
Engineered Equipment for Aircraft and Industry

## AIRBORNE ACCESSORIES CORPORATION

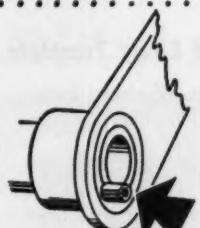
HILLSIDE 5, NEW JERSEY

Circle 599 on Page 19

# Rollpin® replaces 12 different fasteners



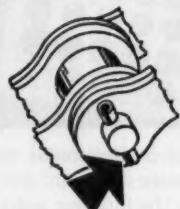
**REPLACING A GROOVED PIN . . .** in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



**REPLACING A KEY . . .** Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.



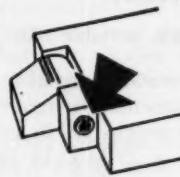
**REPLACING A RIVET SHAFT . . .** Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



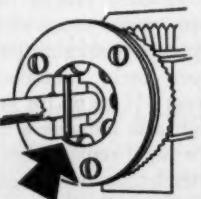
**REPLACING A COTTER PIN . . .** Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



**REPLACING A SET SCREW . . .** to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



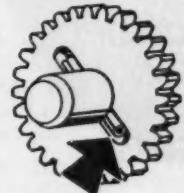
**REPLACING A CLEVIS PIN . . .** here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



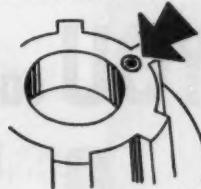
**REPLACING TAPER PINS . . .** in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



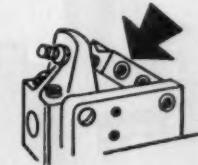
**REPLACING A HEADED PIN . . .** in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



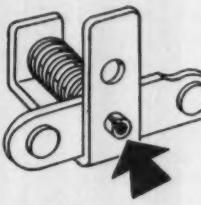
**REPLACING A HUB ON A GEAR . . .** Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



**REPLACING A DOWEL PIN . . .** Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



**REPLACING A BOLT AND NUT . . .** Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



**REPLACING A RIVET . . .** Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

## WHERE CAN YOU USE THIS SIMPLE FASTENER?



Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information. ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-34, Union, New Jersey

Circle 600 on Page 19

**ROLLPIN**  
TRADEMARK

ELASTIC STOP NUT CORPORATION OF AMERICA  
2330 VAUXHALL ROAD, UNION, NEW JERSEY

ENGINEERING DEPT. EQUIPMENT



BOOST Production  
STOP Down-Time Losses with



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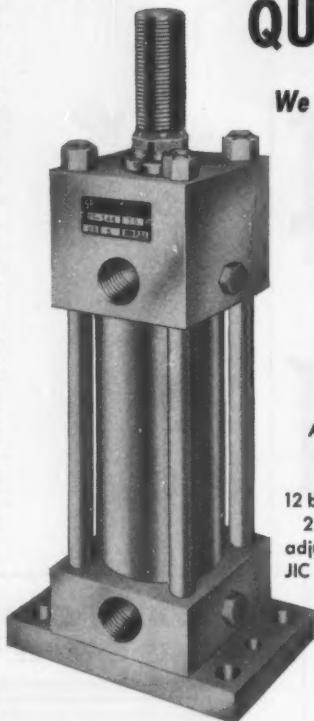
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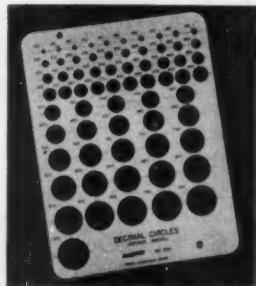
ity. Dulseal is available in 20-yd rolls of various widths and in sheets sized to order, up to 18 x 24 in. Sheets are available plain or pre-printed to individual requirements. Keuffel & Esser Co., Third and Adams St., Hoboken, N. J.

Circle 805 on Page 19

### Decimal Circle Template

contains 66 circles from 0.1 to 1 in. diam

No. 540 decimal circle template contains 66 circles from 0.1 to 1 in. diam. Diameter sizes from 0.1 to 0.5 in. are in increments of 0.01 in., and from 0.5 to 1 in. in increments of 0.02 in. All increments of 0.01 and



0.02 in. are in horizontal rows and all increments of 0.1 in. are in vertical rows, facilitating selection of any size. Template is 0.03 in. matte-finish, mathematical-quality plastic, precision milled with allowance for pencil point, accuracy, and smoothness of line. Size of template is 6 1/8 x 8 1/8 in. Rapidesign Inc., P. O. Box 429, Burbank, Calif.

Circle 806 on Page 19

### Digital Recorder

is 16-track, portable unit

PS-216-D portable digital magnetic-tape instrumentation recorder and reproducer weighs 100 lb and measures 16 1/2 x 25 1/2 x 14 in. The 16-track unit features modular construction and printed-circuit boards. Standard unit is furnished with 1-in wide tape and PCM telemetry tape configuration of 16 tracks per inch. Standard tape speeds from 1 1/8 to 60 ips are available. Unit also includes a tape magazine for rapid replacement of tape or to interchange with continuous-loop magazine. Reels are standard

## PRODUCT-DESIGN BRIEFS FROM DUREZ

- What a solvent cement can do
- Something new in electrical insulation
- A bulletin on plastics

### Stuck?

A good adhesive does a lot more than stick two things together. You can use



today's solvent-type adhesives to:

- smooth out surface contours (as in brake linings and in jet aircraft skins, where adhesives can eliminate the need for projecting rivets);
- distribute stress uniformly over a surface, rather than concentrating it at welded or riveted points;
- build up large structural members from many small components;
- reduce galvanic action between dissimilar metals, and so lessen the risk of corrosion.

One super-sticker in this class sets with only contact pressure and at room temperature; adheres very well to metal, wood, phenolic laminates, glass, and rubber. Block shear tests show 4500 psi at room temperature, and tensile strength is 10,000 psi. The cement has excellent resistance to all ordinary solvents, water, oils, alkalies, and acids; has high capillary attraction and does not shrink.

**We don't make adhesives.** We do make heat-setting phenolic resins that give many of the newer adhesives more gripping power and more permanence. Next time you have a fastening problem, give these new solvent-type adhesives a chance to show you what they can do.

### Stock insulation shapes

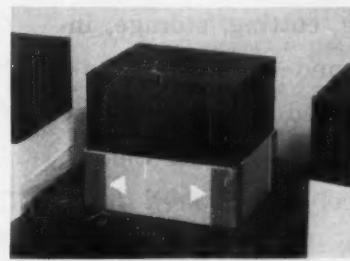
This insulation idea solves three engineering problems at once in a dry-type transformer. You'd find the same ap-

proach helpful in a circuit breaker, a panel, or other heavy-duty electrical gear.

See the plastic angle pieces (below)? They insulate the corners of the laminated steel core from the windings, at the high-stress areas. They take the place of roll-formed fiber. Advantages:

1. Greater mechanical strength. This ends cracking or breaking of insulation when windings are forced into position.
2. Better resistance to moisture. The insulation doesn't swell or shrink, maintains its dielectric strength under the clammiest conditions.
3. Higher heat resistance. The angle is made with glass-reinforced Hetron,® our inherently heat-resistant polyester resin. It meets NEMA GPO-1 specifications, and has UL-recognized flame retardance. It is designed for equipment operating at Class B temperatures (266°F.).

Now for the clincher. You can get flame-retardant structural insulation



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like this *from stock*—in a wide range of cross-section shapes including channels, in widths up to 9½ inches, lengths to 76 inches.

You get them not from us but from the manufacturer, The Glastic Corporation, 4321 Glenridge Road, Cleveland 21, Ohio. The Glastic people will be glad to send you details on stock channels and angles if you write to them.



### Facts without a file

What does a man do when he wants to know more about Durez plastics?

He looks in Sweet's File. There he finds eight pages packed with the what, how, when, where, and why of using Durez materials—phenolic and diallyl phthalate molding compounds, Hetron polyester resins, phenolic resins.

What if he hasn't got Sweet's File handy? He sends us the coupon below, requesting Durez Bulletin D400. The same fact-filled eight pages come to him posthaste.

For more information on Durez materials mentioned above, check here:

- Phenolic resins (12-page bulletin listing applications)
- Hetron fire-retardant polyester resins (data file, including names of fabricators)
- Durez plastics (Bulletin D400)

Clip and mail to us with your name, title, company address. (When requesting samples, please use business letterhead)

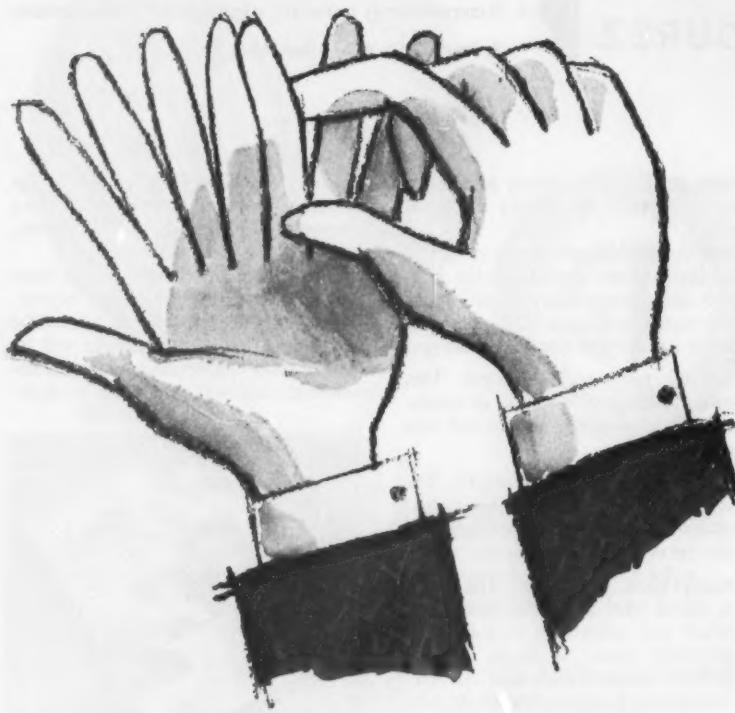
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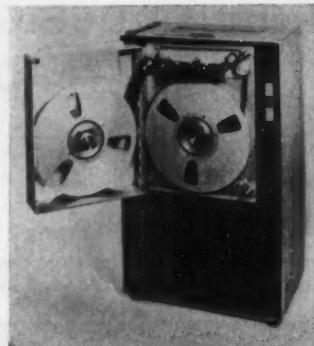
**W-L STEEL SERVICE CENTERS**—Cambridge  
Cleveland • Chicago • Hillside, N. J.  
Detroit • Buffalo • Cincinnati

**AGENTS**—Southern Engineering Company,  
Charlotte, N. C.; Sanderson-Newbould,  
Ltd., Montreal and Toronto

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& COMPANY, INC.**  
134 Sidney St., Cambridge 39, Mass.



## ENGINEERING DEPT. EQUIPMENT



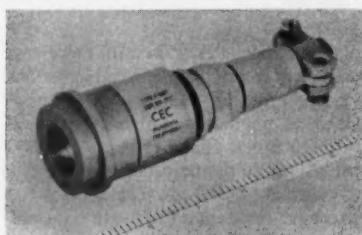
NARTB 10½ in. and can be used with acetate or Mylar tapes of any thickness from 1 mil up. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.

*Circle 807 on Page 19*

### Pressure Transducer

is flush-mounted,  
strain-gage unit

Type 4-327 flush-mounted, strain-gage pressure transducer is obtainable in pressure ranges from 0-100 to 0-5000 psi gage and absolute. It easily measures high-frequency transient phenomena, since pressure-sensitive diaphragm is flush-mounted. Provision is made for adjustment of bridge balance, temperature compensation, and sensitivity external to unbonded strain-gage sensing element. Unit is designed for use where accuracy must be



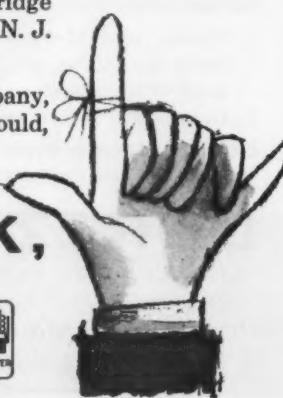
maintained under rugged environmental conditions. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

*Circle 808 on Page 19*

### Regulated Power Supply

for solid-state equipment

Model UVS-1000 bantam-size, voltage-regulated power supply, which is transistor and zener-diode regulated, measures only 4.75 in. wide by 4.5 in. high by 6.25 in. deep.



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Designed to power solid-state equipment, it provides 4 to 36 v at 500 ma. Regulation is better than 1 per cent against line and load, and ripple is less than 5 mv. Output, continuously monitored by a voltmeter and milliammeter, is isolated from input line and chassis ground. Matthew Laboratories, 3344 Ft. Independence St., New York 63, N. Y.

*Circle 809 on Page 19*

### Photoelastic Strain Gage

has near zero  
lateral sensitivity

Strainline photoelastic strain gage is a direct-reading uniaxial strain indicator. Designed with virtually zero lateral sensitivity, it indicates axial strain in direction of gage application only. In addition to axial static and dynamic strains, lateral bending and torque are also indicated. No external instrumentation or connections are required. Linear displacement of visible interference



fringes indicates strain magnitude. Built-in polarizers permit easy use in natural or artificial light. Gage is small, rugged, and easily installed on any surface or material. Groups can be observed or photographed together to provide instantaneous indication of stress distribution over a relatively large area. Type A-75-10 has a  $\frac{3}{4}$ -in. gage length; type A-200-10 has a gage length of 2 in. Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.

*Circle 810 on Page 19*



## Who cares about your Wire Cloth Fabrications?

CAMBRIDGE does . . .

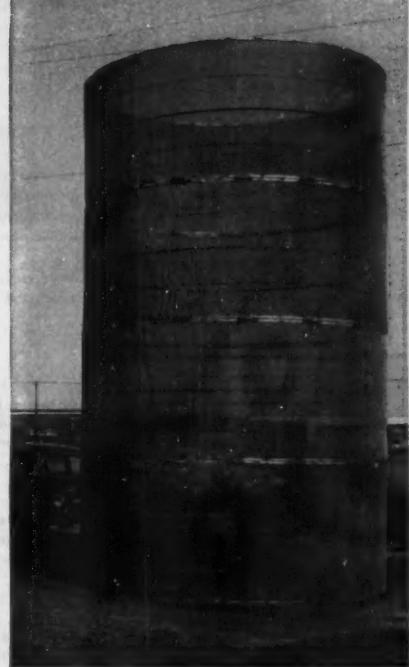
that's why you automatically get service with your order . . . whether you need dozens of midget strainers or a single giant-sized retaining screen.

Careful, competent workmanship and constant inspection assure you of quality . . . modern machinery and accurate scheduling assure you of prompt delivery. And, a Cambridge Field Engineer follows up your order to make sure our product is giving you the best possible service. Let us quote on your next order for wire cloth fabrications. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. We'll work from your prints or draw up prints for your approval. Call your Cambridge Field Engineer . . . he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

### The Cambridge Wire Cloth Co.

Department N • Cambridge 3, Md.

Manufacturers of Wire Cloth,  
Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



# FELT

BY FELTERS

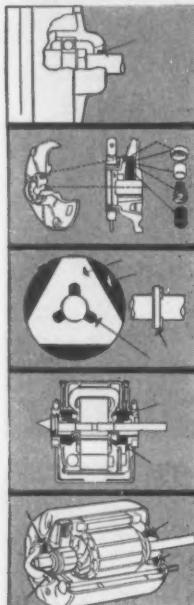
## PROVIDES DEPENDABLE, LOW-COST PARTS FOR **ELECTRIC MOTORS**

Seals . . . wicks . . . lubricators . . . washers . . . gaskets — are all vital electric motor parts that benefit from Felt by Felters.

A special Felters' "Engineered Fabrication" processes felt to specific thickness, density, hardness, and resiliency; and provides special characteristics such as absorption, stiffness, water repellency and flameproofing.

And, new felt and plastic laminates, called PlastiFelts, use synthetics such as Nylon, Teflon, Hycar and rubber to provide an even wider range of application, plus greatly improved performance.

These are some of the many electric motor applications where Felt by Felters offers both a low-cost and high performance material for non-metallic parts.



Felt seal inserted around shaft opening retains grease and keeps out foreign matter.

This self-erlier uses a felt wick, bearing against the shaft under spring pressure, for constant lubrication.

This is a thrust washer designed for double duty as a lubricator by the use of a felt ring and lubricating notches.

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## Professional Viewpoints

... who wants to be boss?

To the Editor:

I have been reading your editorials for quite a few years and find them very interesting. I am not exactly sure what you are lamenting in your January 21 editorial, "Who Wants To Be Boss?"

Frankly, when I see an engineer with 15 or more years' experience personally engaged in design, development, or research, I tend to wonder where he got lost. The engineer who has had reasonable diversity of experience and has learned to think of systems, rather than parts, and of engineering rather than the engineering sciences, is able to contribute infinitely more to the accomplishment of work as the planner, organizer, and director of work done by less qualified personnel, both professional and nonprofessional, than as the personal executor of such work.

The man who by directing the work of subordinates as extensions of himself can produce results greater than the sum of the efforts of everyone, including himself, as individuals, is rather obviously contributing more than any individual worker, and he is entitled to greater rewards.

This can best be illustrated mathematically. Assume man *A* is a widely experienced man and can personally accomplish 100 units of work value per day. Men *B*, *C*, *D*, and *E* are less experienced and can produce 80, 60, 40, and 20 units of work value. Total work value of the five men is 300 units. Now, assuming that under *A*'s direction, *B*, *C*, *D*, and *E* can produce an average of 75 value units, we have the same 300 units, and *A*'s value is the same as when he works as an individual. If the average production can be raised to 80 units, or 320 units total, *A* is contributing 120 work units to the total, or 20 percent more than he can as an individual.

Even if the output of the group

is only equal to the sum of the individuals working separately, there is advantage in that the junior personnel are going to develop faster under proper supervision and direction than with each individual struggling along on his own.

In short, at any given level of personal technical competence, the man who can effectively direct and lead the works of others contributes more than the lone worker, and he is entitled to greater reward.

The same reasoning applies to the true sales engineer (not merely mislabeled salesmen who can only refer to the catalog and price list), the engineer-attorney, etc. The additional qualifications and the combinations involved permit greater contribution to the desired end, and therefore, justly merit greater prestige and remuneration than the man with purely technical competence of the same level.

—R. P. JOHNSTON  
Scituate, Mass.

*To the Editor:*

I believe that the condition which you outlined creates a vicious circle which retards our technological progress: An executive-administrative position seems to be the reward for a job well done in engineering, design, or R & D. This is very regrettable, for in our complex state of technology it takes a great deal of study, time, and energy for the engineer to arrive at a point where the sum total of his accumulated intellectual potential allows him to start "producing." If an individual is shifted to an executive-administrative position at this juncture, his potential is lost, although it may have been built up at a considerable expense to his company; his work as an engineer stops just at the moment when his contribution becomes most valuable. This does not only mean a loss to the advancement of our technology, but it leads also to a regrettable conclusion: The shift to an executive-administrative position is considered a sign of success, i.e. a promotion in salary and in position, and is therefore highly desirable. It also means abandonment of the individual effort in favor of a supervisory career.

The men who, many years after graduation, are still doing engineer-

When **NORTON** needed a compact motor\* they came to **JACK & HEINTZ**

Norton sought to develop the lightest, smallest, most attractive door-operator available . . . one whose entire mechanism could fit a slender door header.

Key to design was a motor that could meet these specs: 1) shorter than 5"; 2) less than 4" in diameter; 3) totally enclosed, nonventilated; 4) high torques; 5) special shaft; 6) special end bell. The result is seen below.

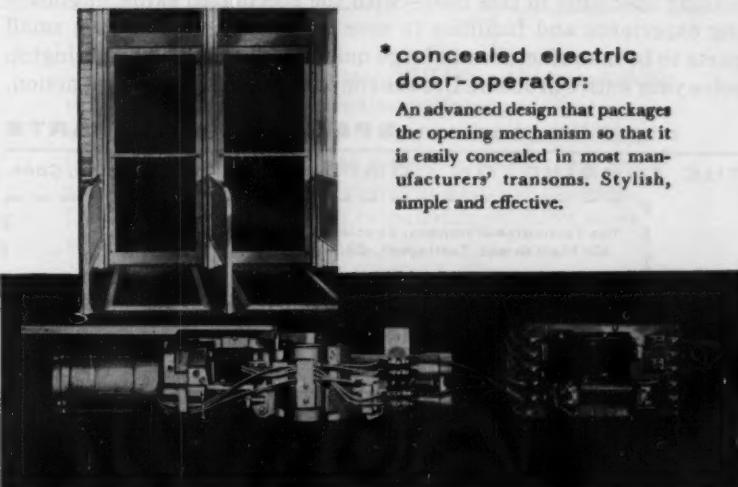
Like Norton designers . . . and many others . . . design *your product* to do a job and to sell, not to fit a motor.

Whatever your motor need, you set the electrical, physical, mechanical and environmental conditions. We'll do the rest. Our range is  $\frac{1}{6}$  to 3 hp, up to 15 hp for submersible motors.

For further data, write to: Jack & Heintz, Inc., Commercial Motor Division, 17626 Broadway, Cleveland 1, Ohio.

\*concealed electric door-operator:

An advanced design that packages the opening mechanism so that it is easily concealed in most manufacturers' transoms. Stylish, simple and effective.





*When close tolerances are Vital—*

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### PROFESSIONAL VIEWPOINTS

ing, design, or development work, must therefore mainly be those dedicated to the pursuit of these subjects, and who did not abandon this work in favor of a "higher" career, despite the drawbacks involved. It is disquieting to think that the men to whom we are looking for the advancement of our technology should work under such a handicap.

These conditions seem to be felt by our younger people, although they are not often analyzed. The energetic type who wishes to "succeed" often regards engineering, design, or R & D as a mere stepping stone, to be left behind as fast as possible.

We have to blame only ourselves for this state of affairs and for the dangers which it entails. We cannot reproach a young man for his desire to be successful in his chosen career. Being successful, however, is not synonymous with making as much money as fast as possible. Development, design, and engineering should offer desirable careers by themselves, and the men who practice them should know that particular achievements in these areas will lead to positions which are commensurate in income and status with those of administrators or executives. Only then can we expect that an engineering career will attract and retain the type of brains and personalities needed in our technological race.

In my opinion, the cause responsible for much of this attitude is a latent contempt for learning and for the vast knowledge which it imparts. An exception is usually granted to such areas as atomic science and the space technology of the post-sputnik era. In many other areas, however, a formal approach based along theoretical or analytical lines is derided as a sign of insufficient practical experience or know-how. This is incorrect, for our rapidly expanding technology makes it increasingly difficult to rely on past practical experience alone. Frequently we are forced to formulate our next steps on the basis of analytical and theoretical thinking; practical experience can only be of valuable assistance if a close enough analogy of condition exists.

—R. M. REICHL  
R. M. Reichl Co.  
Forest Hills, L. I., N. Y.

THE ENGINEER'S

# Library

## Recent Books

**Machine Shop Operations and Setups.** By H. W. Porter, C. H. Lawshe, and O. D. Lascoe; 449 pages, 5 1/4 by 8 1/2 in., clothbound; published by American Technical Society, 848 East 58 St., Chicago 37, Ill.; available from MACHINE DESIGN, \$5.50 per copy postpaid.

By providing information on machine tools, operations, and setups, this book may help those not initiated in machine shop practice. National surveys were utilized to select material for discussion.

Initial chapters deal with precision and semiprecision measuring tools, and bench tools. Then, drill presses, lathes, shapers, millers, and grinders are discussed. Final chapters concern steels and their alloys, heat treating, and machinability.

A basic trade vocabulary in the lathe and milling machine areas is incorporated in the text.

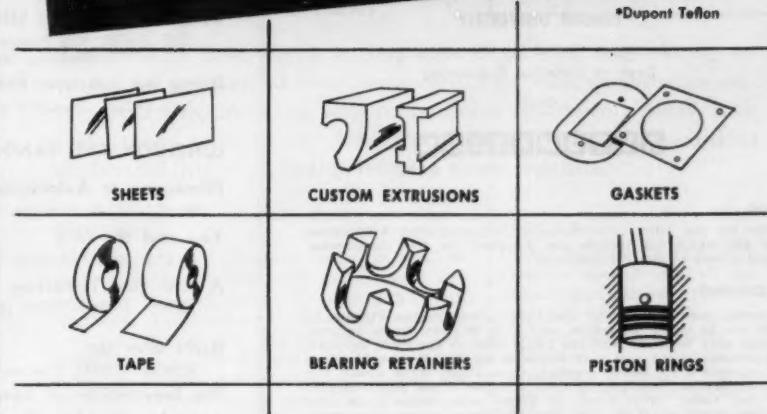
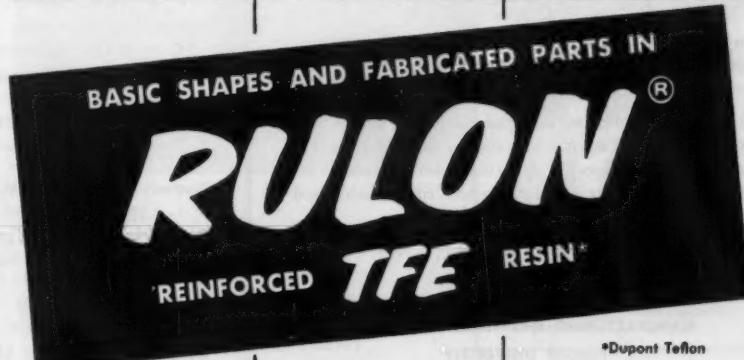
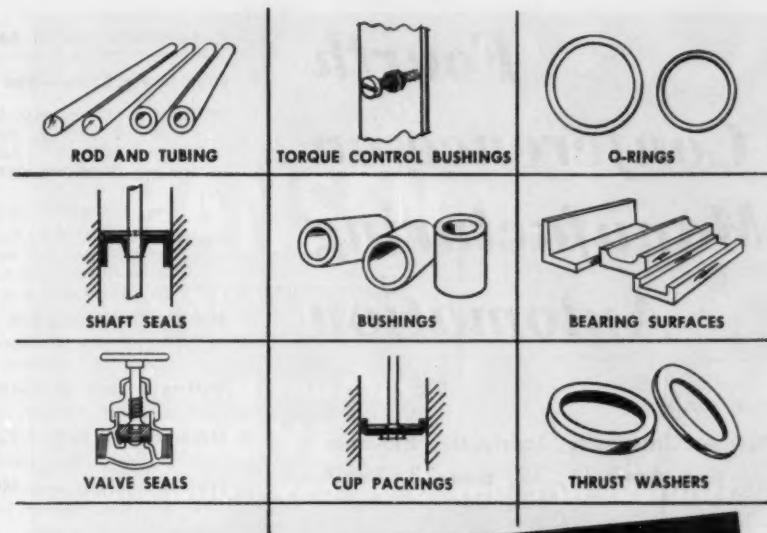
**Cemented Carbides.** By Paul Schwarzkopf and Richard Kieffer; 349 pages, 6 1/2 by 9 1/2 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from MACHINE DESIGN, \$15.00 per copy postpaid.

A comprehensive and up-to-date treatment of cemented carbides is presented. Opening chapters furnish background information and describe methods of producing carbides and other metallic refractories. Middle chapters describe mechanical and physical properties of cemented carbides in commercial production. Final chapters concentrate on applications to machine-tool, defense, and other industries.

## Association Publications

**Developing a Product Strategy.** 352 pages, 6 1/2 by 9 1/2 in., clothbound; published by and available from American Management Assoc., 1515 Broadway, New York 36, N. Y.; \$7.50 per copy.

This report on product planning,



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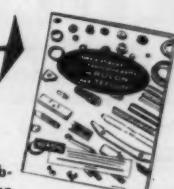
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## **CONFERENCE TOPICS AND SPEAKERS**

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W. W. KUYPER, Manager, Manufacturing Engineering, Large Steam-Turbine Generator Dept., General Electric Co.  
R. L. SCHOENBERGER, Manager, Production Engineering Dept., R. R. Donnelley & Sons Co.

W. A. STADTLER, Director of Manufacturing Research, I.B.M. Corp.

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E. McFERRIN, Vice President-Sales, Giddings & Lewis Machine Tool Co.  
W. K. STOKES, Vice President-Sales, Alvey Ferguson Co.

### **Manufacturing Research and Automation**

T. R. BUNNELL, Manager of Manufacturing Services, Semiconductor Div., Sylvania Electric Products Inc.

### **Getting a Grip on Costs and Payoff**

K. H. MEYER, Manager, Mfg. Services, Reliance Electric & Engineering Co.

### **Organizing to Reduce Costs through Automation**

C. D. EVANS, Ass't. Manager, Mfg. Research, International Harvester Co.

### **Process Analysis and Machine Procurement**

H. A. LEONE, Manager, Headquarters Mfg. Lab., Westinghouse Electric Corp.

### **Automating Assembly**

C. H. STANDISH, President, Designers for Industry Inc.

### **Integrating the Packaging Operation**

WILLIAM WOOD, President, Processes Research Inc.

### **Techniques for Parts Handling**

R. H. BONNER, Application Engr., Industrial & Machine Tool Operations, Radio Corp. of America

### **Dispensing Problem Materials in Process**

L. E. HARPER, President, Omega Machine Co. Div., B-I-F Industries Inc.

### **Mechanization for Distribution**

E. J. HARDY, Ass't. Supt., Engineering Equipment Development, Western Electric Co.

### **Temperature Controls**

H. G. PAYNE, Manager, Measurement Group Sales Product Div., Foxboro Co.

### **Using Relay Control Effectively**

ZEKE SMITH, Vice President & Tech. Dir., Potter & Brumfield Div., American Machine & Foundry Co.

### **Doing the Job with Photoelectrics**

J. J. LAREW, Product Engr., Specialty Control Dept., General Electric Co.

## **LUNCHEON AND BANQUET TOPICS AND SPEAKERS**

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The following persons plan to attend the AUTOMATION CONFERENCE, April 11, 12, and 13, 1960 (name and title, please):

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production, and promotion shows how top management, finance, research, engineering, production, and sales contribute to successful product development. Specific development programs based on co-operation and co-ordination of every department are described by executives from both large and small companies.

Initial chapters deal with organization, research, and product screening. Then, engineering, marketing, and financial requirements are covered.

**Filler Metal Comparison Charts.** 44 pages,  $8\frac{1}{2}$  by 11 in., paperbound, stapled; available from American Welding Society, 33 West 39th St., New York 18, N.Y. \$2.50 per copy.

Brand names of 78 companies are listed together with welding rod and electrode comparison charts. Fifteen AWS-ASTM specifications are involved.

**The Design of Welded Pipe Fittings.** By P. H. R. Lane and R. T. Rose; 49 pages,  $7\frac{1}{4}$  by  $9\frac{3}{4}$  in., paperbound, stapled; published by and available from British Welding Research Assoc., 29 Park Crescent, London, England.

This booklet provides information on details concerned with the welding of pipelines and fittings. Stress and fatigue data are presented for application in practical design work.

### Manufacturers' Publications

**Moleculonics.** By Edward L. Holbrook; 54 pages,  $4\frac{1}{4}$  by 7 in., paper-covered, plastic-ring binding; published by and available from Modernair Corp., 400 Preda St., San Leandro, Calif.; \$1.00 per copy.

Fundamentals of pneumatic circuitry are analyzed and discussed. No mathematics, formulas, or reference charts are used in the explanations. Practical approach is employed in analysis and solution of pneumatic-system problems.

**Thermistors and Varistors.** 39 pages,  $5\frac{1}{2}$  by  $8\frac{1}{2}$  in., paperbound; available from Victory Engineering Corp., 536 Springfield Rd., Union, N.J.; \$1.00 per copy.

This revised data book provides applications information about ther-

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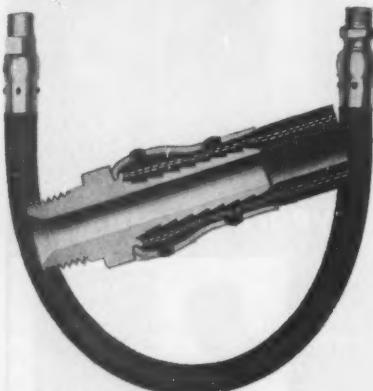
If you must have performance in a synchronous motor . . . investigate Hansen SYNCHRON motors. Over 200 different types of output available. Hansen engineers will work with you to find a satisfactory solution to special application or design problems. For further information or assistance, contact the nearest Hansen representative or write direct to:

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mistors, varistors, thermal-conductivity cells, electronic controls, and thermal, electronic, and physical-sensing devices. New material on resistance-temperature curves, voltage-current curves, and silicon-carbide varistors is presented.

### Government Publications

**NASA Technical Notes.** Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

**TN D-98. Optimum Proportions of Truss-Core and Web-Core Sandwich Plates Loaded in Compression.** By Melvin S. Anderson of Langley Research Center; 26 pages, 7% by 10½ in., paperbound, side-stapled; \$0.75 per copy.

Optimum proportions based on weight-strength ratios are determined for sandwich plates under simulated inplane compressive loading. Two constructions which can be welded are designated the single-truss-core and double-truss-core sandwich. The web-core sandwich is also studied. Weight efficiency of the three configurations at room temperature is then compared with efficiency of honeycomb construction and of solid plates of high-strength aluminum.

**TN D-163. Handbook of Structural Stability. Supplement to Part III—Buckling of Curved Plates and Shells.** By George Gerard, New York University; 23 pages, 7% by 10½ in., paperbound, side-stapled; \$0.75 per copy.

Recent results on buckling of curved shells are reviewed and interpreted in terms of analyses previously presented. Theoretical results are presented on plastic buckling of moderate-length circular cylinders under torsion and external pressure. Solutions have also been obtained for buckling of circular cylinders under torsion and external pressure by both the initial-imperfection and the finite-deflection-energy approaches. Experimental tests provide data on buckling of cylinders under external pressure and under combined internal pressure and compression.

**TN D-208. An Investigation of Non-propagating Fatigue Cracks.** By A. J. McEvily Jr. and W. Illig, Langley Research Center; 29 pages, 7% by 10½ in., paperbound, side-stapled; \$0.75 per copy.

An attempt is made to account for non-propagating fatigue cracks by examining stresses at the tip of a fatigue crack. A study shows the possibility that such cracks may form under constant-amplitude cyclic loading if the crack closes during compression, or, if the effective crack radius is larger than that of the initial notch. Results of experimental work on steel and aluminum alloys compare favorably with predictions.

**TN D-212. Axial-Load Fatigue Tests of 2624-T3 and 7075-T6 Aluminum-Alloy Sheet Specimens under Constant-and-Variable-Amplitude Loads.** By E. C. Naumann, H. F. Hardrath, and D. E. Guthrie, all from Langley Research Center; 37 pages, 7% by 10½ in., paperbound, side-stapled; \$1.00 per copy.

Sheet specimens with a theoretical elastic stress concentration factor of 4.0 were tested with the load amplitude held constant or varied by steps, to approximate a gust-load history. Test data were analyzed by assuming linear cumulative damage. A limited statistical evaluation was used to confirm conclusions.

**TN D-230. Tension, Compression, and Fatigue Properties of Several SAE 52100 and Tool Steels Used for Ball Bearings.** By G. Sachs, R. Sell, and V. Weiss, Syracuse University; 48 pages, 7% by 10½ in., paperbound, side-stapled; \$1.25 per copy.

Mechanical properties of several vacuum-melted, tool (hot-work) steels used for high-temperature ball bearings are compared with those of the common high-carbon, high-chromium, SAE 52100 bearing steel. Three electric-furnace heats and one induction-vacuum-melted heat were investigated.

Yield strength in tension and compression, tensile strength, and S-N curves for two main heats of 52100 steel were determined at 350 F. Determined at 500 F were yield strength in tension and compression, tensile strength, and S-N curves for three tool steels at a hardness of Rockwell C 62.

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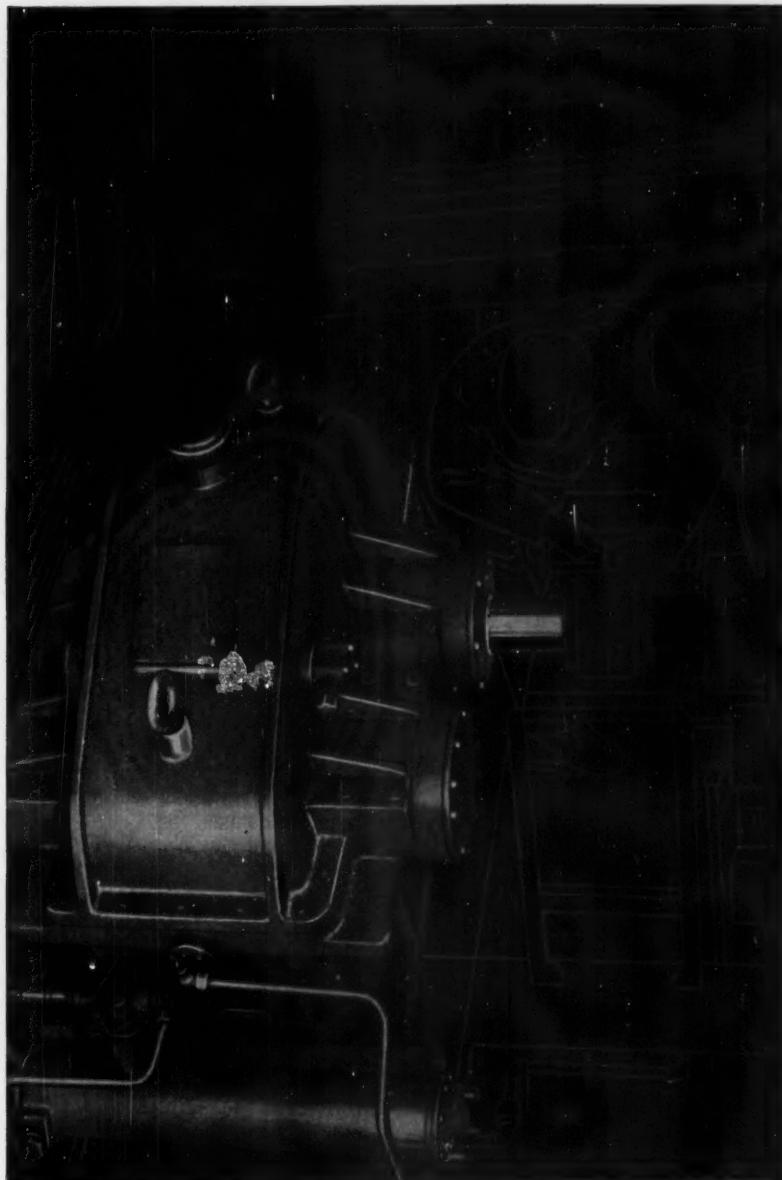
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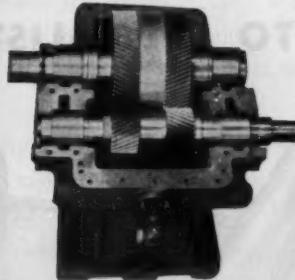
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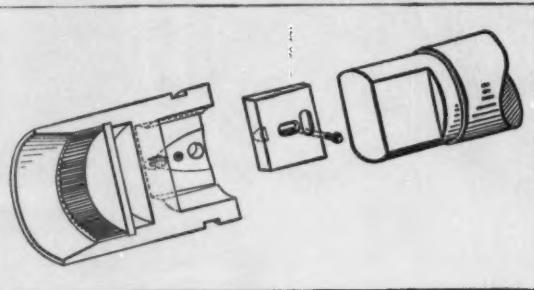
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## NOTEWORTHY **Patents**

### **Quick-Acting Shaft Coupling**

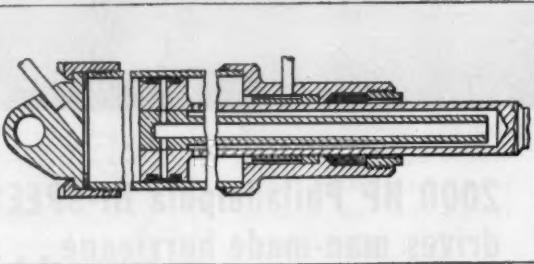
Driven and driving shaft members can be quickly connected or released with a key-mounted coupling. A pair of tapered keys forced longitudinally against the



flattened end portion of the driven shaft lock the coupling in place. To disconnect, the tapered keys are released and moved out of engagement by a cam wrench. Patent 2,919,137 assigned to Koppers Co., Inc., by Pierce Hollingsworth.

### **High-Temperature Hydraulic Cylinder**

Cooling of a high-temperature hydraulic cylinder results from controlled leakage past the piston rings. A tube is arranged within the hollow piston rod to route

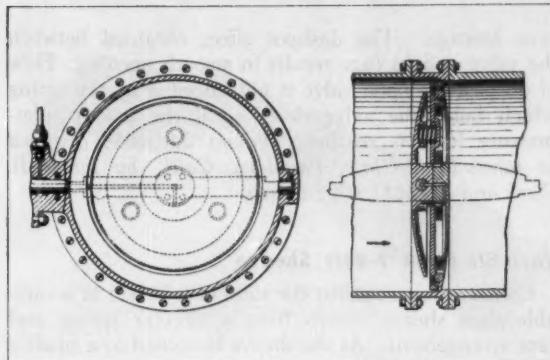


the leakage fluid through a major portion of the rod length which is subjected to high-temperatures during operation. Patent 2,918,903 assigned to General Motors Corp., Detroit, by Howard M. Geyer.

### **Combination Poppet-Butterfly Valve**

A hybrid poppet-butterfly valve uses bellows elements to permit universal adjustment of the valve assembly to the valve seat. The poppet valve is supported between a pair of disks attached to a hollow shaft. In the closed position, springs force the poppet valve to engage its seat in the wall of the flow passage. To

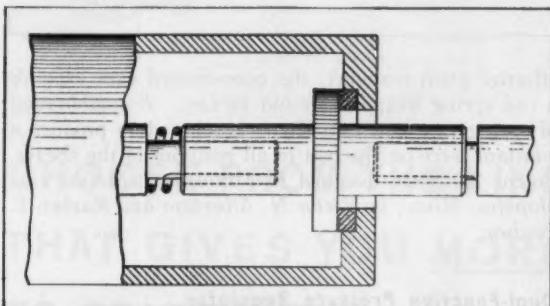
## NOTEWORTHY PATENTS



open, air pressure is admitted to the bellows through the hollow shaft. The valve is forced off the seat far enough to permit rotation of the assembly as a butterfly member. To close, the assembly is rotated back into closed position and air pressure is released from the bellows. Patent 2,910,266 assigned to Thiokol Chemical Corp. by Vincent Condello and Roger F. White.

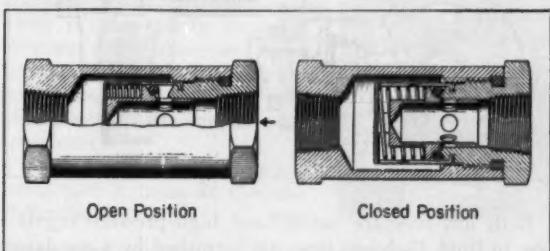
#### **High-Temperature Seal-Coupling**

A shaft-seal assembly for use in high-temperature applications incorporates a stub shaft to permit use of a face-type seal. The shaft includes a wear ring which



is spring loaded against a stationary seal ring. The seal ring is mounted on one wall of the enclosure through which the shaft extends. Patent 2,919,939 assigned to Gits Bros. Mfg. Co., Chicago, by Raymond H. Andresen and Hilmar A. Andresen.

#### **Preassembled Check Valve**



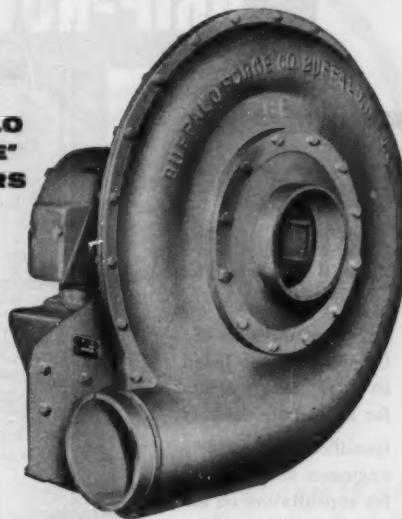
Visual inspection of operation before final assembly is possible with a cage-type check valve. In the closed position, a metal-to-metal seal, plus an O-ring, pre-

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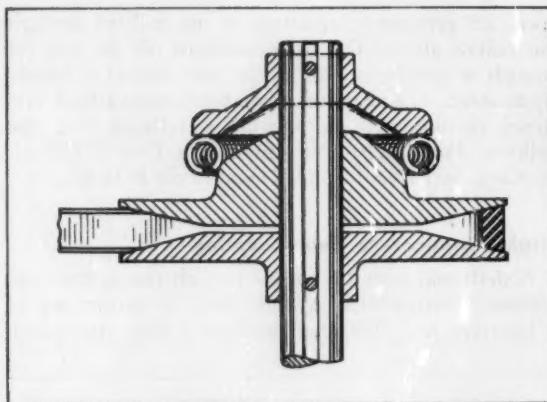


### NOTEWORTHY PATENTS

vent leakage. The dashpot effect obtained between the valve and its cage results in smooth opening. Flow of oil past the open valve is not impeded by the spring which holds the valve closed until the proper inlet-pressure level is reached. Patent 2,918,083 assigned to James-Pond-Clark, Pasadena, Calif., by James R. Clark and Lloyd G. Christensen.

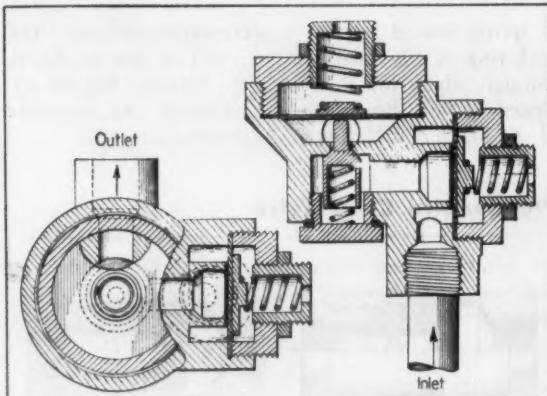
### Variable-Pitch V-Belt Sheave

Constant force against the sides of a V-belt in a variable-pitch sheave results from a circular spring and cam arrangement. As the sheave is opened to a smaller



effective pitch diameter, the cone-shaped cam expands a coil spring wrapped around its face. A combination of spring rate and cam shape is selected to produce a constant force on the belt in all positions of the sheave. Patent 2,916,926 assigned to Minneapolis-Moline Co., Hopkins, Minn., by Victor N. Albertson and Rueben E. Paulson.

### Dual-Function Pressure Regulator



Both low-pressure cut-off and high-pressure regulation in fluid discharge lines are furnished by a regulator with two valve elements. A spring-loaded diaphragm interrupts the flow when inlet pressure drops below a preset value. Outlet pressure is maintained at a predetermined level by a regulating valve which is con-



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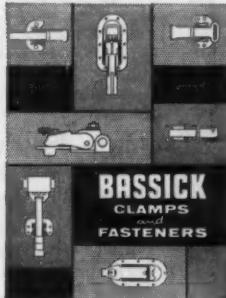
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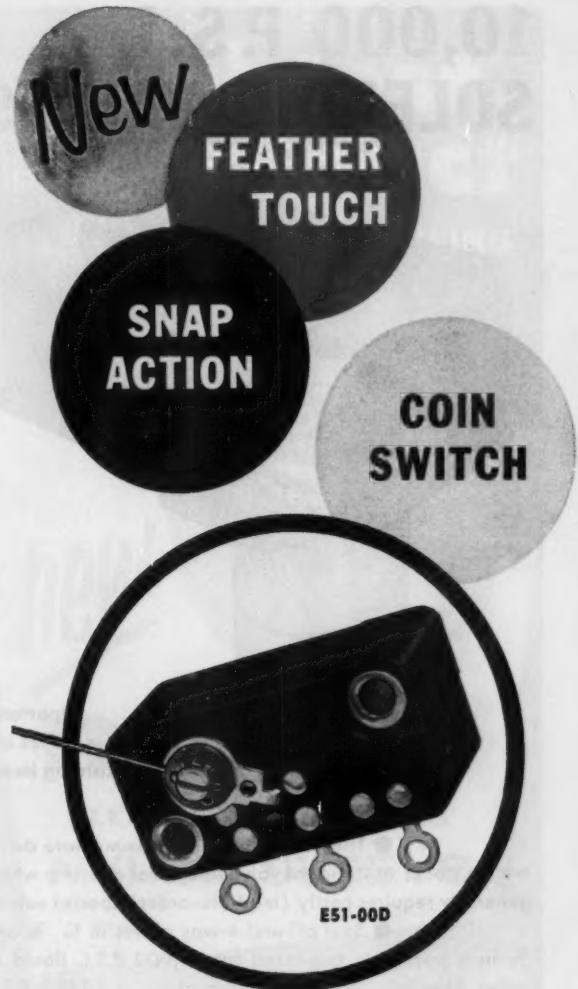
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Circle 616 on Page 19



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Circle 617 on Page 19

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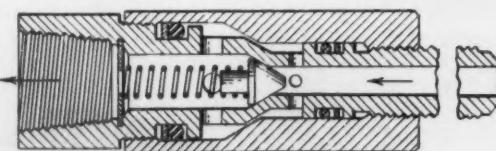
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## NOTEWORTHY PATENTS

trolled by a second spring and diaphragm combination. Patent 2,918,082 assigned to H. D. Hudson Manufacturing Co., Chicago, by August H. Pinke.

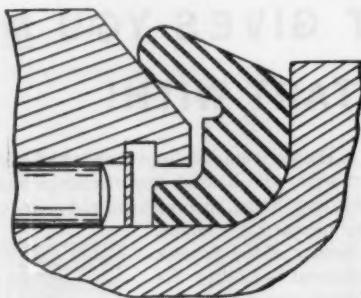
### Reversible-Flow Check Valve

Free flow in one direction with controlled or checked flow in the opposite direction is provided by an in-line type hydraulic control valve. In the free-flow direction, the force of the fluid disengages the conical-shaped



valve from its seat. Flow in the opposite direction seats the valve. However, openings in the adjustable sleeve permit reverse flow. Amount of reverse flow is controlled by the clearance between the valve body and the adjustable sleeve. Patent 2,924,237 assigned to L & L Mfg. Co., East Detroit, Mich., by George S. Ellis.

### Universal-Joint Seal



Passage of displaced air and old lubricant during pressure lubrication of universal-joint elements is permitted by a cup-shaped sealing ring. Resilience of the ring holds the lip against the sealing surface during normal operation, but permits the lip to open slightly under pressure developed during lubrication. Patent 2,916,896 assigned to Dana Corp., Toledo, Ohio, by Fred F. Miller, Jr.

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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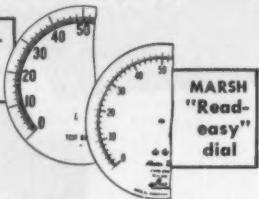
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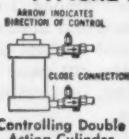
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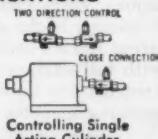
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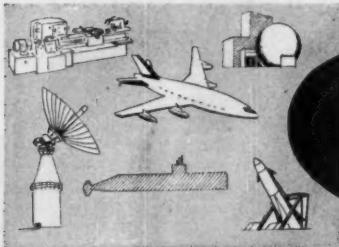
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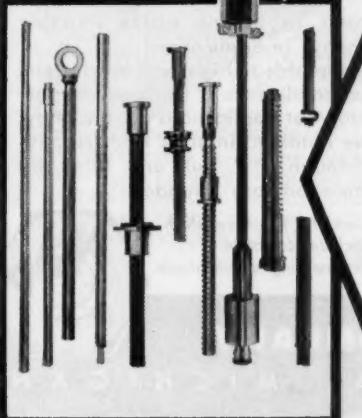
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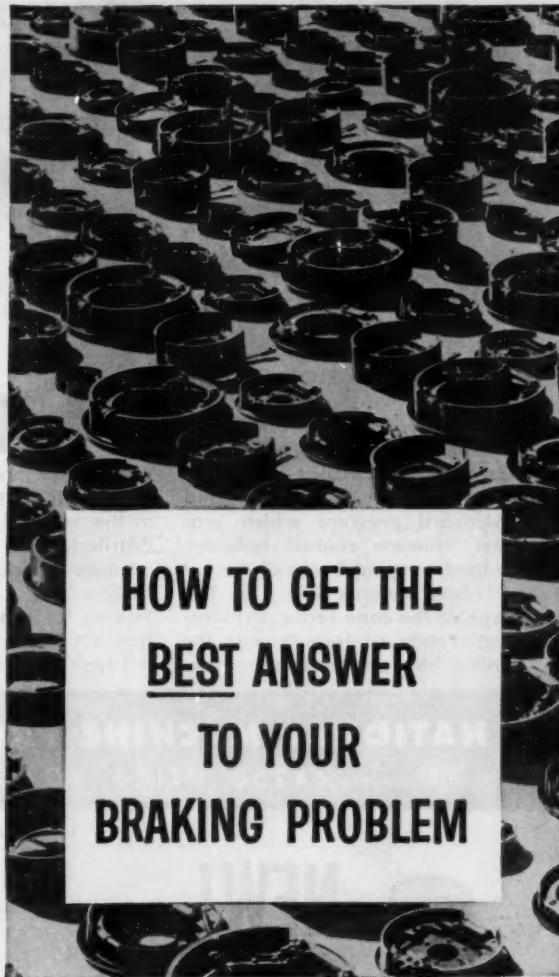
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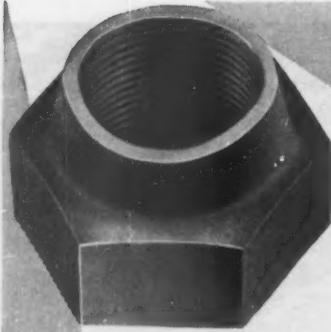


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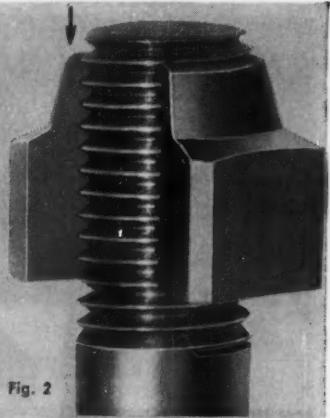
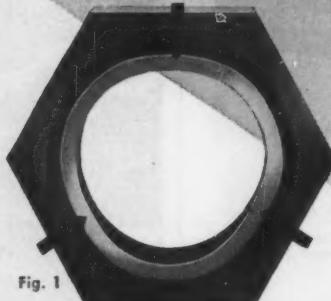


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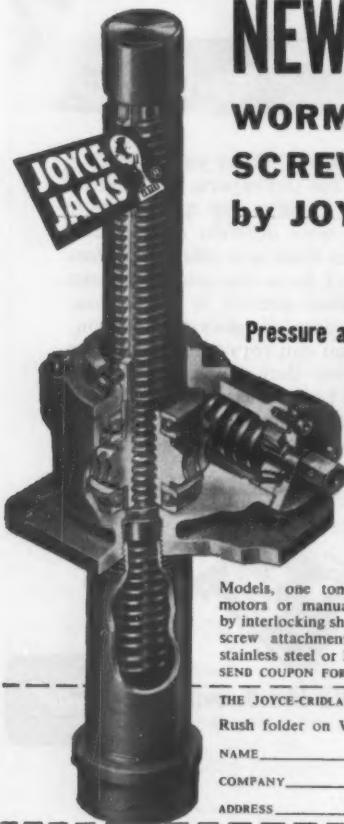


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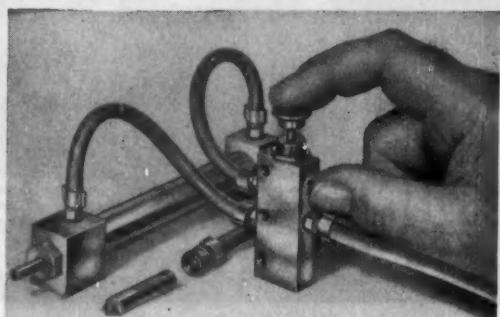
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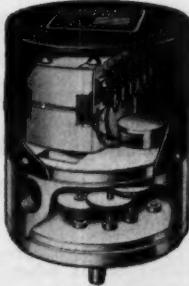
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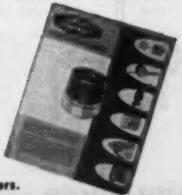


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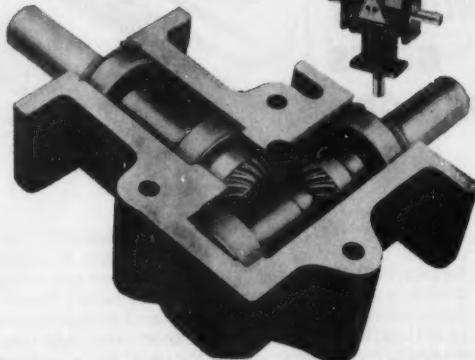
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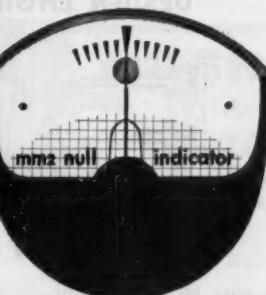
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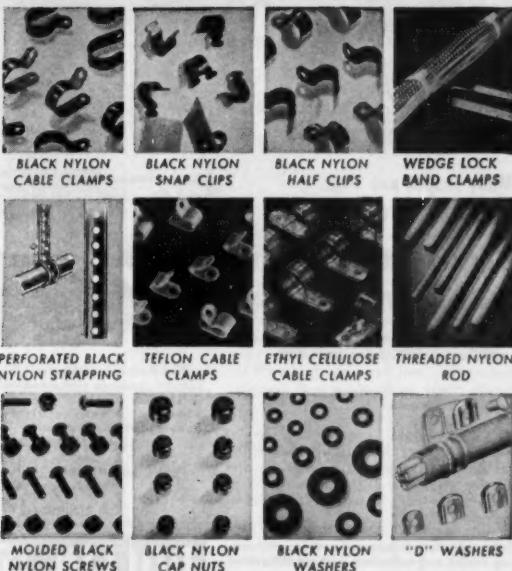
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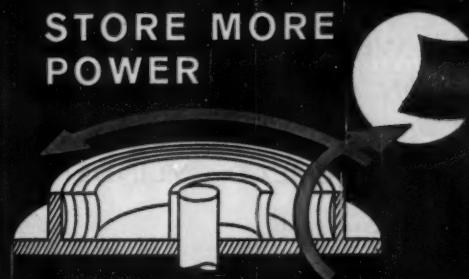
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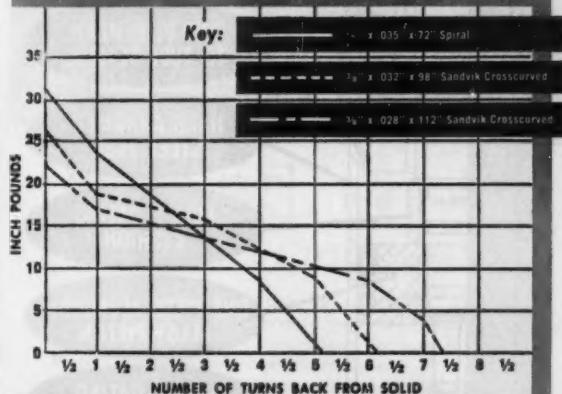
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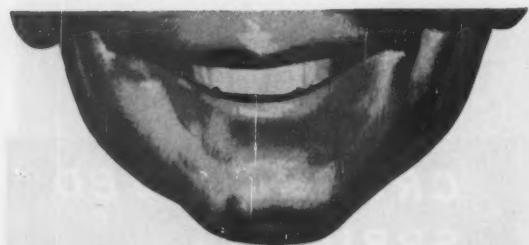
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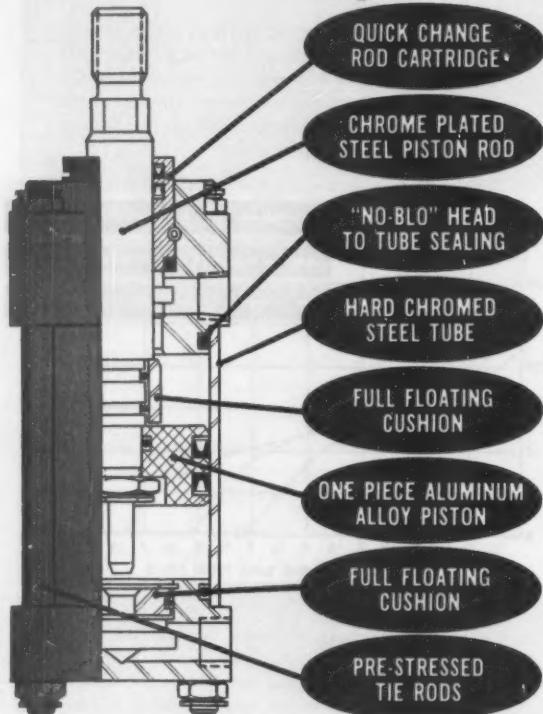
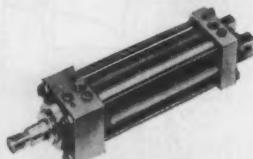


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AND . . . ADD ALL THESE  
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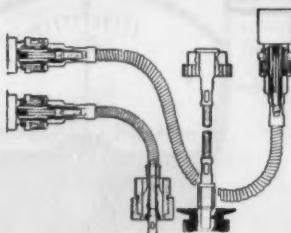
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### Flexible Shafting For The DESIGN ENGINEER



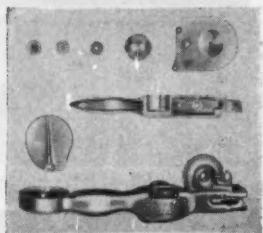
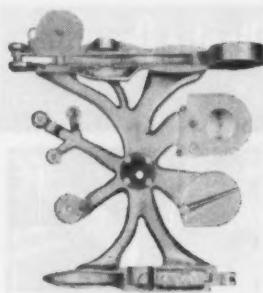
Designs may be improved or developed to their highest degree of efficiency only when the engineer is free to place his drive or driven units wherever necessary in order that he may save space, facilitate servicing, or provide for easy assembly. Flexible Shafting utilized within or in conjunction with a product enables the design engineer to reduce the number of parts, economize on space, and simplify the grouping of working units. He is able to do this because of the ability of flexible shafting to transmit power over, under, and around obstacles between the drive and driven units.

A good example of this is the above illustration. Although this diagram represents a small, compact unit, obstacles in the path of the shafts would present no serious problem to the designer. The shafts merely curve around the obstacles. When the unit is in production, none of the shafts have to be aligned; they are merely fastened to their respective units by ferrules on each of the shafts. For complete information concerning Flexible Shafting, write on your letterhead to F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

Circle 640 on Page 19

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One Shot...

8 PARTS!



Many shapes and sizes  
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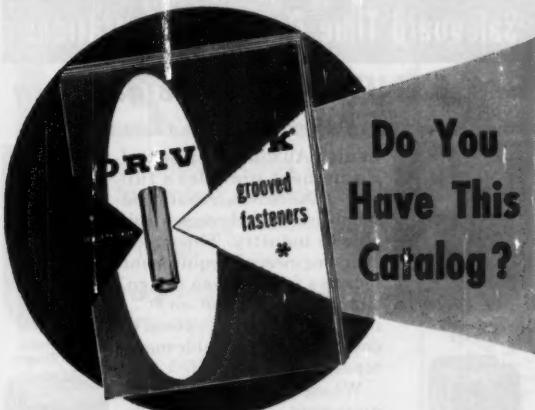
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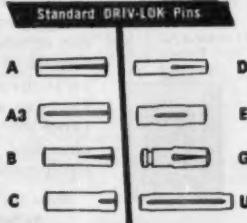
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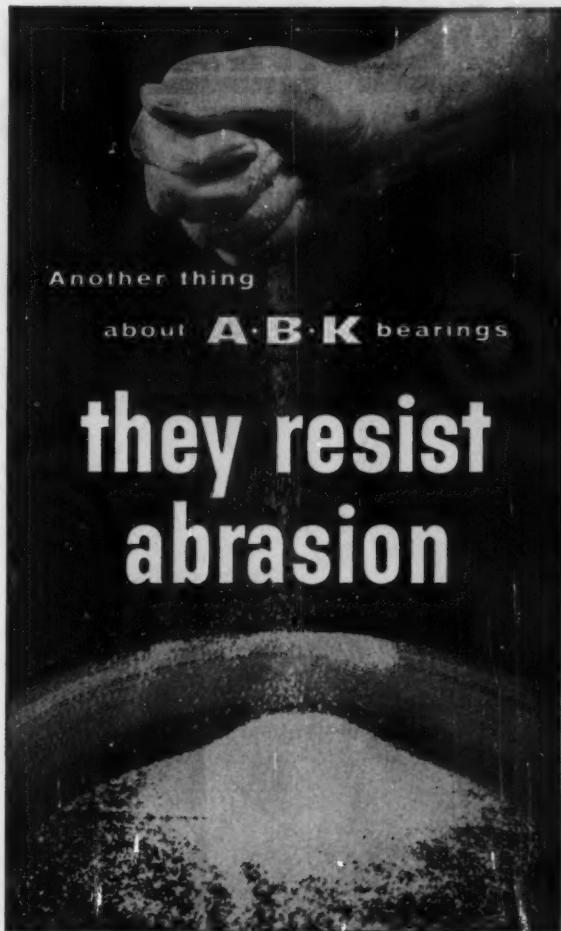
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**they resist abrasion**



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material of 1001 uses

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COMPANY

AMERICAN BRAKEBLOK DIVISION  
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Rockford, Illinois



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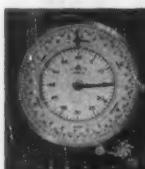
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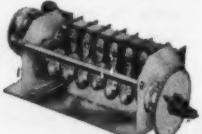
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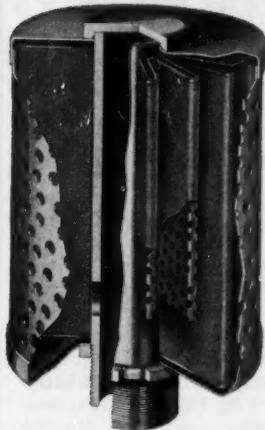


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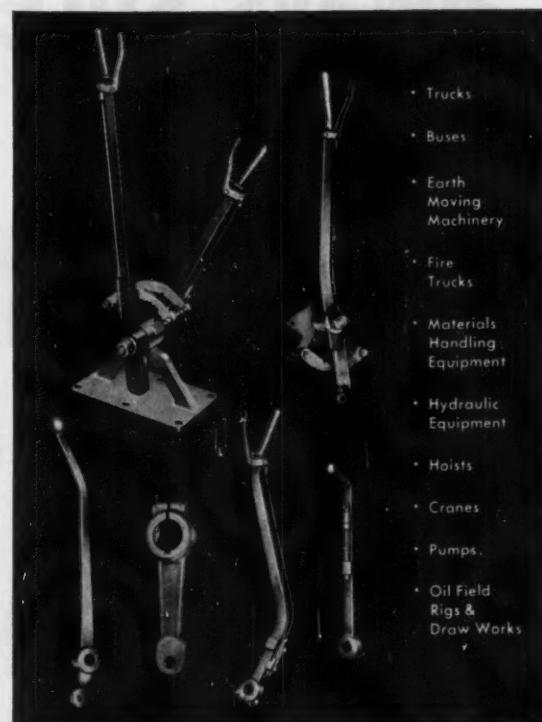


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**eliminate tooling costs**

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Batavia 3, New York

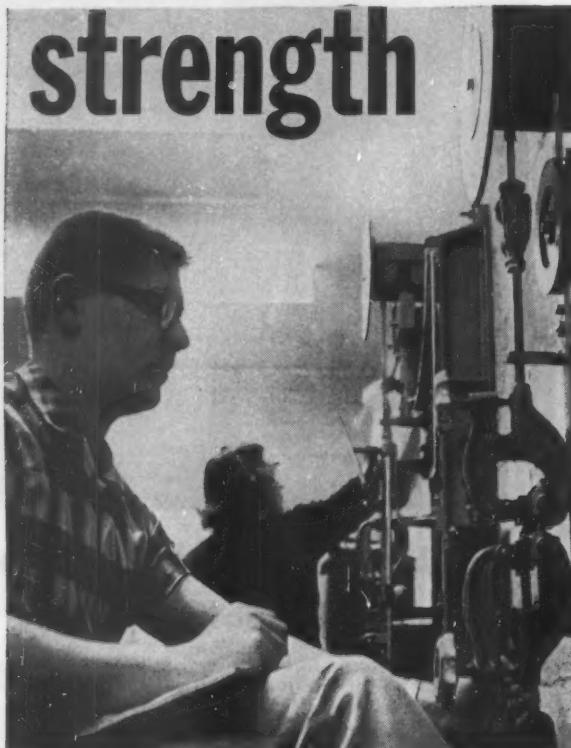
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On this Scott Tensile Tester in our lab at Buena Vista, Virginia, all our fabrics are thoroughly checked for tensile strength and tear resistance.

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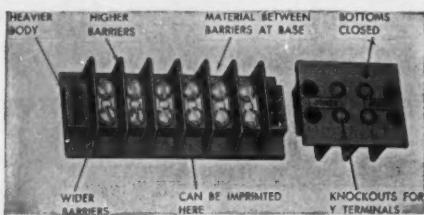
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CHICAGO 24, ILLINOIS  
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## Design Guide to “Adjustable-Speed Drives”

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

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Circle 653 on Page 19



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Ever consider using Belleville Springs for brakes and clutches? They're especially effective on the flat part of the load-deflection curve—where load remains constant over an appreciable deflection. With proper design, you can get all the load and deflection normally required yet allow for considerable tolerances as well.

SOLON specializes in manufacture of PRECISION Belleville Springs. We would be glad to work with you on your requirements. Write today for your free copy of our design manual, "Belleville Springs," which lists our standard manufacturing tolerances on different grades—as well as necessary curves for their design.

### Solon Manufacturing Company

South Miles Road • Solon, Ohio

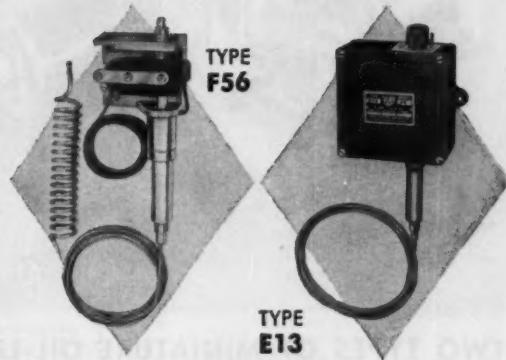
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## Improved Design REMOTE BULB TEMPERATURE CONTROLS

F56  
E13

WIDE RANGE

CALIBRATED



The F56 and E13 are functionally similar controls. Type F56 is a wide range, uncalibrated, skeleton unit designed for use in ovens, incubators, and other applications where space or weight is a limiting factor. Type E13 is a narrow range, calibrated, enclosed unit intended for similar applications but under conditions where an enclosure and external adjustment knob and dial are desirable. Explosion proof unit, Type E98, is also available.

#### Temperature Ranges

F56 . . . up to maximum limits of -150° to +150°F, 70° to 370°F, or 100° to 650°F.

E13 . . . 100° or 200° spans between -150° and +650°F limits.

#### Switch Ratings

15 or 20 amps at 115 or 230 volts AC. DC switches also available.

#### Switch Types

N.O., N.C., or Double Throw, no neutral position.

#### Adjustments

F56 . . . slotted range adjustment screw on top, uncalibrated settings. E13 . . . external knob and pointer, calibrated settings.

#### Electrical Connections

F56 . . . 12-inch lead wires attached directly to switch terminals.

E13 . . . to internally located terminal block via conduit opening in enclosure.

#### Capillary Tube Length

6-foot standard length. Other lengths available.

#### Mounting

E13 . . . surface mounted in any position by means of dog ears. May be flush mounted.

F56 . . . Surface mounted in any position by holes drilled in base of bracket. May be flush mounted.

**UNITED ELECTRIC** manufactures a complete line of temperature, pressure, and vacuum controls. For additional data on the remote type temperature controls, including types F56 and E13, request Section 200 of our new catalog.



**United Electric Controls**

COMPANY

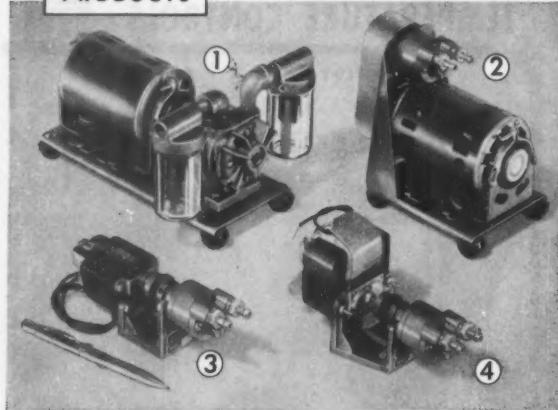
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319

ROTARY AIR  
**GAST**  
PRODUCTS

## NEW for 1960



### TWO TYPES OF MINIATURE OIL-LESS **GAST** VACUUM PUMPS and AIR COMPRESSORS

(1) Model 1030-V110-  
206 Vac. Pump,  
1/20 h.p. Up to 1  
c.f.m.; to 15° vac.

(2) Model 0330-V112-  
206 split phase  
1/20 h.p. motor,  
.48 c.f.m. Up to 20°  
vac. or 15 p.s.i.g.

(3) Model 0330-V102A-  
151 series wound  
motor. Up to .67  
c.f.m. To 20° vac.  
or 10 p.s.i.g.

(4) Model 0330-V110-  
202 shaded pole  
motor. Up to .35  
c.f.m. To 20° vac.  
or 10 p.s.i.g.

(5) (Below) Model  
0630-P103 Com-  
pressor, up to .6  
c.f.m. To 25 p.s.i.g.  
or 24° vac.

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Now — where space is very limited — you can provide moderate vacuum or pressure with one of these two types (3 series) of Gast semi-miniature Air Pumps.

They run entirely without oil. Carbon vanes lubricate themselves, producing a completely oil-free air blast or exhaust. Rotary design is simple, trouble-free and positive in air displacement.

The largest Model 1030 (1 above) delivers up to 1 c.f.m. running open at 3450 r.p.m. Model 0630 (5 below) has identical exterior, delivers up to .6 c.f.m. Smaller type 0330 (2, 3, 4 above) is shown with a choice of motors to suit various pump applications, both a.c. and d.c. With a rotor diameter smaller than a penny, Model 0330 produces up to .67 c.f.m. (open) at 6000 r.p.m.!

These "semi-miniatures" may solve a problem for you — investigate today!

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GAST MANUFACTURING CORP., P.O. Box 117-P  
Benton Harbor, Michigan

See Catalog  
in Sweet's  
Design File

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ROTARY

"Air may be your answer!"

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- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

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## DIMCO-GRAY COMPANY

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Circle 657 on Page 19

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WANTED: Mechanical engineers for design of process equipment. Creative men with ME degrees and 0 to 5 years' experience can grow in permanent positions with a 75-year young growth company in Rochester. Benefits include group incentive, top medical coverage, non-contributory pensions. Send resume, giving salary requirements, to R. D. McVay, Industrial Relations, Box C-O, The Pfaudler Co., a division of Pfaudler Permutit Inc., Rochester 3, New York.

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# backtalk—

## —Ten Years on the Masthead



Looking as though he is looking for something, Ben Hummel may very well be keeping a watchful eye for the messenger who brings ten-year commemorative pins to Penton veterans. Ben, one of our two associate managing editors, came to *MACHINE DESIGN* on March 17, 1950, as an associate editor.

After receiving his degree in mechanical engineering from Lehigh University and for the ten years prior to March, 1950, Ben was with the Hamilton Watch Co., Lancaster, Pa.; he served as supervisor of the watch design section for the last four years of his hitch there. A born overseer of technical writing, Ben also trained student engineers in this art.

Some of Ben's managing-editor duties have turned him into a joiner—he is a member of the Society for Experimental Stress Analysis, the Standards Engineers Society, the Society of Business Magazine Editors, and he serves on the General Committee of the Machine Design Division of ASME.

## —Be Our Guest

You probably noticed that this issue's editorial (Page 133) is signed by someone other than a *MACHINE DESIGN* editor. This occurrence points up two facts: 1. We don't often receive visitors on our editorial page. 2. Guests are welcome there. As we have said before, *MACHINE DESIGN* is your magazine; our standing invitation to submit material for publication includes the inner sanctum of the editor's page. If you have something to say to your fellow engineers, feel free to enter this verbal soap-box derby. We'll be happy to consider your ideas.

## —Engineering for Adolescents

More than likely, some leisure time of many *MACHINE DESIGN* readers is spent working elementary algebra problems for their offspring. No matter how he feels about ninth-grade algebra, chances are that a member of the engineering profession pays above-average attention to children's education. And, it is natural that an engineer be especially aware of science programs. Anyone who would like to bolster his knowledge by reading current literature will be interested in a bibliography distributed by SAMA—a ten-page booklet which lists books, pamphlets, and articles dealing with science education and careers. Its aim is to "close the gap between a national awareness and united action" in improving science and education facilities. Called *Closing the Gap*, the booklet is available free from Scientific Apparatus Makers Association, 20 N. Wacker Dr., Chicago 6, Ill.

## —Now Hear This

In the July 9, 1959, issue of *MACHINE DESIGN* we published a report on employment preferences of engineering graduates which showed that most A and B students do not seek government jobs. In the January, 1960 issue of the *NSPE Legislative Bulletin*, one item begins, "A recent survey among top college graduates which showed that only 29 per cent of them preferred Government employment has been challenged by the Navy, which says that 60 per cent of college graduates it hired recently were in the top scholastic echelon of their class."

We don't mean to declare war on the Navy, but we must take exception to the reasoning behind its objection. Consider a hypothetical set of figures: There are 1000 A and B graduates, 30 per cent of whom prefer to work for the government. OK, so the Navy needs 500 engineers. It hires the 300 A and B boys plus 200 less clever fellows. The group is—sure enough—composed of 60 per cent A and B students; but still only 30 per cent of the top graduates have decided to see the world.

Don't miss this column next time—we're going to take up the square knot.

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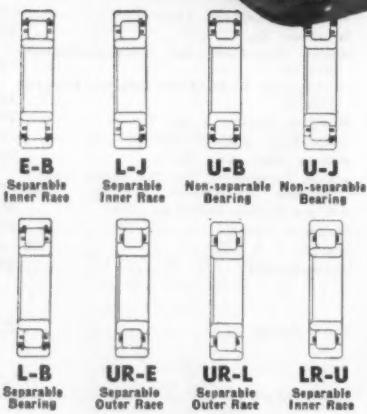
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